2

Code KT

HEAT PIPE TECHNOLOGY

CUMULATIVE VOLUME
March 1971

(NASA-CR-135953) HEAT PIPE TECHNOLOGY: A BIBLIOGRAPHY WITH ABSTRACTS Cumulative Volume (New Mexico Univ.) ~~239~~ 243 p HC $14.00 CSCL 20M

N73-33900

Unclas
G3/33 15822

TECHNOLOGY APPLICATION CENTER
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87106

TAC BIBLIOGRAPHIC SERIES NUMBER 1

TAC-BIBL-1 (71/1)

243

HEAT PIPE TECHNOLOGY

A BIBLIOGRAPHY WITH ABSTRACTS

CUMULATIVE VOLUME

March 31, 1971

ASSEMBLED BY

THE HEAT PIPE INFORMATION OFFICE

of

THE TECHNOLOGY APPLICATION CENTER
INSTITUTE FOR SOCIAL RESEARCH & DEVELOPMENT
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

PREFACE

During the era since the launching of the first Sputnik, Americans have risen to the challenge of space exploration with vast scientific and technical research programs. Recognizing the fact that much of this space research and development might prove valuable to the general public and commercial enterprises, NASA's Technology Utilization Program developed a system of six centers for disseminating the results of this research. The Technology Application Center at The University of New Mexico is the center serving the Rocky Mountain Southwest. Its mission is to promote the beneficial use of new technology.

One of the activities of the Technology Application Center has been to identify new, high-interest areas of technology and to assemble and update abstract volumes on these subjects. Dr. K. T. Feldman, Jr., of the College of Engineering, Josef E. Spitzer, an Applications Engineer at the Technology Application Center, and Eugene Burch, Assistant Director of the Center, conceived the idea of a comprehensive reference to the area of Heat Pipe Technology, which would be kept up-to-date by the Center's wide contacts in heat pipe research. This volume is the product of that concept.

Today, the engineer or scientist who is not constantly keeping himself aware of new developments in his field of expertise soon finds his knowledge obsolete. In addition, estimates indicate that at least 10 percent of our Nation's $12.5-billion-plus research-and-development expenditures is spent on duplication of previous efforts. To meet these challenges in an area of declining research budgets and tremendous environmental problems, we at the Technology Application Center are sincerely committed to a continuous interaction with those forward-looking individuals, companies, and industries seeking to develop a better nation and world.

William A. Shinnick
Director
Technology Application Center
University of New Mexico

INTRODUCTION

Since the invention of the modern heat pipe at Los Alamos in 1963, the growth of information on pipes has been rapid and diffused. At the present time, publications on heat pipe are increasing at a rate of about 200 per year. Consequently, a considerable number of important references may not be widely known and may be difficult to obtain. Examples of such references include government laboratory reports, industrial contractor reports, university research reports, and some journal articles.

Recognizing the need for complete and up-to-date information on heat pipes, the Heat Pipe Information Office was established at The University of New Mexico. The most modern literature-search techniques as well as the assistance of many workers in the field have been used to compile an extensive bibliography with abstracts on all types of heat pipe references including patents. Also, a library containing essentially all of these articles has been established. In addition to publishing this bibliography with abstracts, the Heat Pipe Information Office will publish a quarterly update of the bibliography and will provide copies of references. Some foreign references have been translated into English.

Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to notify the Office of omissions.

K. T. Feldman, Jr.
Technical Editor
Professor of Mechanical Engineering
Director of Cooperative Educational Program
School of Engineering
University of New Mexico

PRECEDING PAGE BLANK NOT FILMED

ACKNOWLEDGEMENTS

This volume is, in large part, based on the efforts of Josef Spitzer, who devoted a vast amount of time and energy in preparing, editing, and promoting Heat Pipe Technology, and to Dr. K. T. Feldman, Jr., the technical editor, whose bibliographies, documents, and encouragement and guidance assisted in the success of this effort. Appreciation is extended to Mr. Monte F. Mott, Chief of the Patents and Technology Utilization Division of the NASA Pasadena Office, whose collection of Heat Pipe Patents was made available for this work. The cooperation of Dr. C. A. Busse of EURATOM and his efforts in collecting and announcing papers and references in the European sector were extremely helpful.

Thanks are further extended to staff members of the Technology Application Center, Walter W. Long, Associate Director; Mark Money, Administrative Officer; and especially to Eugene Burch, Assistant Director, all of whom participated in the successful publication of this volume.

This publication was further made possible by the Technology Utilization Program of NASA, from which the Technology Application Center derives the major portion of its support, and by the close cooperation of the College of Engineering of The University of New Mexico.

W.A.S.

PRECEDING PAGE BLANK NOT FILMED

CONTENTS

A. GENERAL INFORMATION, REVIEWS, SURVEYS

65001 THEORY OF HEAT PIPES
Los Alamos Scientific Lab., N. Mex., T. P. Cotter, 26 Mar. 1965, 36 p refs (Contract W-7405-ENG-36), (LA-3246-MS) Avail:TAC

A heat pipe is a self-contained structure which achieves very high thermal conductance by means of two-phase fluid flow with capillary circulation. A quantitative engineering theory for the design and performance analysis of heat pipes is given.

65002 ON THE OPERATION OF HEAT PIPES
B. D. Marcus, Applied Thermodynamics Dept. Physical Electronics Laboratory - Physical Research Div., TRW Space Technology Laboratories, Redondo Beach, Cal. (9895-6001-TU-000) 19 p 4 refs Avail:TAC

Description of a heat pipe and analysis of the transfer processes involved. A heat pipe is a closed system capable of transferring large quantities of thermal energy between a source and sink which exhibit only a small temperature difference. Hypothesized external and internal heat pipe configurations are diagrammed and the optimum wick thickness is considered. Included are a description of nomenclature and appendices on contact angles and thermal conductivities.

66001 SURVEY OF LOS ALAMOS AND EURATOM HEAT PIPE INVESTIGATIONS
Los Alamos Scientific Lab., N. Mex., W. A. Ranken and J. E. Kemme [1965], 12 p refs Presented at the IEEE Thermionic Conversion Specialist Conf., San Diego, Calif. (Contract W-7405-ENG-36), (LA-DC-7555: CONF-651049-3) Avail:TAC

A review is presented of investigations of heat pipes for thermionic diode uses. The theory of heat pipes is presented. Experimentally obtained properties of heat pipes and several possible pipe designs are discussed.

66002 EVAPORATION-CONDENSATION HEAT TRANSFER DEVICE
Grover, George M. (to U.S. Atomic Energy Commission). U.S. Patent 3,229,759. Jan. 18, 1966.

A heat transfer device comprising a sealed tube of niobium-1% zirconium alloy, the inside surface of the tube being, for the most part, covered by capillary means and a small amount of lithium wetting the capillary means is described.

67001 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION/SANDIA LABORATORIES HEAT PIPE CONFERENCE, VOLUME I
Sandia Corp., Albuquerque, N. Mex., Space Isotope Power Dept., Oct. 1966, 91 p refs Conf. Held in Albuquerque, N. Mex., 1 Jun 1966 (Contract AT(29-1)-789), (SC-M-66-623: CONF-660645) Avail:TAC
CONTENTS:

1. STATUS OF THE ENGINEERING THEORY OF HEAT PIPES, T. R. Cotter (Los Alamos Scientific Lab), p 5-9 (See N67-26792 14-33)
2. HEAT PIPE CAPABILITY EXPERIMENTS, J. E. Kemme (Los Alamos Scientific Lab), p 11-25 refs (See N67-26793 14-33)
3. OPERATING LIMITS OF THE HEAT PIPE, A. Carnesale, A. H. Cosgrove, and J. K. Ferrell (N. Carolina State Coll.) p 27-44 refs (See N67-26794 14-33)
4. FEASIBILITY STUDIES OF SPACE RADIATORS USING VAPOR CHAMBER FINS, H. C. Haller and S. Lieblein (NASA Lewis Res. Center) p 47-67 refs (See N67-26795 14-33)
5. NOTES ON HEAT PIPES AND VAPOR CHAMBERS AND THEIR APPLICATION TO THERMAL CONTROL OF SPACECRAFT, S. Katzoff (NASA Langley Res. Center) p 69-89 refs (See N67-26796 14-33)

67002 HEAT PIPE ANALYSIS
G. H. Parker (Westinghouse Electric Corp., Pittsburgh, Pa.) and J. P. Hanson (Pennsylvania, University, Philadelphia, Pa.) Avail:TAC IN: ADVANCES IN ENERGY CONVERSION ENGINEERING; AMERICAN SOCIETY OF MECHANICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, MIAMI BEACH, FLA., AUGUST 13-17, 1967, PAPERS. [A67-42485 24-03] New York, American Society of Mechanical Engineers, 1967, p. 847-857. 13 refs

The paper assesses the performance capabilities and limitations of heat pipes through a parametric analysis and, to a limited extent, comparison with experimental heat pipe results. A number of parametric curves are presented to provide quantitative insight regarding the physical phenomena that govern heat pipe operation and to provide heat pipe design guidelines. The principles of heat pipe operation are briefly discussed along with a concise history of their development.

67003 HEAT PIPE
Feldman, K. Thomas Jr.; Whiting, Glen H. (SC-TM-66-2632) (Sandia Corp., Albuquerque, N. Mex.). Mar. 1967. Contract AT(29-1)-789. 14 p. Avail:TAC

The heat pipe is a unique and simple heat transfer device which has an effective thermal conductivity several hundred times that of copper. The operating principles and characteristics of the heat pipe are described. Performance characteristics, possible applications, and current research and development activities are discussed.

67004 THE HEAT PIPE, A UNIQUE AND VERSATILE DEVICE FOR HEAT TRANSFER APPLICATIONS
RCA - Electronic Components and Devices; Direct Energy Conversion Dept., Lancaster, Pa., (RCA REF 994-619) Avail:TAC (17p)

Description of a heat pipe with a discussion of how it works and possible areas of application. A heat pipe is an efficient and economic heat transfer device for use at any temperature range. Using the principles of vapor heat transfer and capillary attraction, the heat pipe is so highly efficient and versatile that it finds numerous space age applications.

67005 DAS WAERMEROHR (HEAT PIPE)
Pruschek, R, Schindler, M, Moritz, K. Chemie-Ingenieur-Technik v 39, n 1 Jan 13, 1967 p 21-6 Avail:TAC

As high-efficienty heat conductor, the versatile, enclosed heat pipe, which requires no supervision during operation, promises a simple solution to many heat transfer problems, particularly in space travel; the inner wall of the tube is lined with wick which is saturated with a liquid heat conveyor; it evaporates at the heated end of the tube, condenses at the cool end, and is brought back to initial point through capillary action of the wick; theory of heat pipe is developed, and data on pipes so far constructed are given. 21 refs. Before VDI, Bad Mergentheim West Germany, Oct. 1966. In German with English abstract.

67006 HEAT PIPE
Feldman, K. T. Jr., Whiting, G. H. Mech Eng v 89 n 2, Feb 1967, p. 30-3 Avail:TAC

Simple and inexpensive device which can transport thermal energy at efficiencies greater than 90% and, by relying on evaporation, condensation, and surface tension characteristics of working fluid, is able to transfer up to 500 times as much heat per unit weight as can solid thermal conductor of same cross section; heat may be transferred to or from heat pipe by conduction, radiation, or convection, and it may be used with variety of heat sources such as electric heaters, open flames, or nuclear heat sources. 11 refs.

68001 THE HEAT PIPE
G. Yale Eastman (Radio Corporation of America, Lancaster, Pa.). Scientific American, vol. 218, May 1968, p. 38-46 Avail:TAC

Description of the heat pipe, essentially a closed, evacuated chamber the inside walls of which are lined with a capillary structure, or wick, that is saturated with a volatile fluid. The operation combines vapor heat transfer and capillary action. Vapor heat transfer is responsible for transporting the heat energy from the evaporator section at one end of the pipe to the condenser section at the other end. The capillary action is responsible for returning the condensed working fluid back to the evaporator section to complete the cycle. The device can be several thousand times as effective in transporting heat as the best metals. Its special properties are high thermal conductance, temperature flattening, heat-flux transformation, and separation of heat source from heat sink. It shows promise of being immediately useful in many areas of technology.

68002 CRITICAL REVIEW OF HEAT PIPE THEORY AND APPLICATIONS
Cheung, Henry (UCRL-50453) (California Univ., Livermore. Lawrence Radiation Lab.). July 15, 1968. Contract W-7405-eng-48. 70p. Avail:TAC

A critical review of the theories and experiments relating to heat pipes was made to provide an introductory reference which summarizes and interprets the information useful in practical applications. The areas to be studied to extend current knowledge are indicated. The open literature up to March 1968 is evaluated and interpreted.

68003 THE HEAT PIPE
Daniel B. Dallas, ASTME Student Quarterly, Fall 1968. Avail:TAC (3p)

Description of a heat pipe with a discussion on how it works and different factors that affect its working like operating temperatures, latent heat, thermal conductivity, viscosity, surface tension, wetting ability and boiling point. Mentions the Atlas Agena Flight where a heat pipe was used and other potential areas of application.

69001 APPLICATIONS OF THE HEAT PIPE
K. Thomas Feldman, Jr. (New Mexico, University, Dept. of Mechanical Engineering, Albuquerque, N. Mex.) and Glen H. Whiting (Sandia Corp., Sandia Laboratory, Space Isotope Power Dept., Albuquerque, N. Mex.). Avail: TAC Mechanical Engineering, vol. 90, Nov. 1968, p. 48-53. 13 refs.

Discussion of applications of the heat pipe, a device consisting of a tube, a wick, and a fluid that can transfer heat at a very rapid rate. The heat pipe has a fraction of the weight, and several hundred times the heat transfer capability of solid copper, silver, or aluminum. Because it operates almost isothermally and can act as a thermal transformer, it can readily couple thermal power sources to energy-conversion devices. The heat pipe can go around corners, can absorb vibration, and can be flexible. Applications are described which are particularly suited to thermal control of aerospace and terrestrial energy-conversion systems.

69002 INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968. PROCEEDINGS.
Conference sponsored by the European Nuclear Energy Agency. Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969. 1438 p. In English and French. Avail:TAC
CONTENTS:

FOREWORD. H. Neu (EURATOM and Comitato Nazionale per l'Energia Nucleare, Ispra, Italy). p. 5.

WELCOMING ADDRESS. L. Boxer (European Nuclear Energy Agency, Paris, France). p. 21, 22.

WELCOMING ADDRESS. H. Kramers (EURATOM and Comitato Nazionale per l'Energia Nucleare, Ispra, Italy). p. 22-24.

INTRODUCTION. H. Neu (EURATOM and Comitato Nazionale per l'Energia Nucleare, Ispra, Italy). p. 24-27.

69003 HEAT PIPES FUNCTION ISOTHERMALLY AND ADAPTABLY
F. G. Arcella and G. S. Dzakowic (Westinghouse Electric Corp., Astronuclear Laboratory, Pittsburgh, Pa.). Space/Aeronautics, vol. 52, Aug. 1969, p. 58-60, Avail:TAC

Study of the heat pipe, a closed mass transport device which effectively transports heat at a temperature that remains nearly constant over its entire surface. Because it is also light in weight, requires no pumping power, and may be made in many different shapes, it is highly suitable for space applications. Latent heat associated with phase change and capillary action are the two phenomena which afford the heat pipe its exceptionally good thermal conductance. Temperature control through choice of fluid is discussed. It is emphasized that wick structure is crucial for pumping. A wide range of fabrication methods is described.

69004 THE HEAT PIPE--A PROGRESS REPORT
G. Y. Eastman (Radio Corporation of America, Lancaster, Pa.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS. INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03). Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 873-878. Avail:TAC

Review of heat pipe development work at RCA since December 1963. More than 1100 heat pipes have been fabricated in a variety of sizes and shapes for operation over a range of temperatures and power levels. Much of this work has been performed under energy conversion programs, many of them government sponsored, some classified. A few comments are made on future applications of the heat pipe within the energy conversion context as well as some of the desirable spinoffs of this space-age technology in the commercial and industrial marketplace.

69005 THE HEAT PIPE AND ITS OPERATION
Schwartz, J., Heat Transfer/Thermodynamics Research Group 353, Jet Propulsion Lab., Pasadena, Calif., Avail:TAC 32p.

This report, a general survey of the present state-of-the-art of heat pipe theory and applications, is derived from many sources as well as investigations carried out at JPL by the author. The primary purpose of the report is to introduce the reader to the heat pipe and discuss its operation and capabilities. For the reader who may be interested in specific heat pipe applications, there is enough preliminary information available in the body of the report as well as references which list a large number of related papers.

69006 HEAT PIPE TRANSFERS HEAT WITH NEARLY UNIFORM TEMPERATURE
Westinghouse R & D Letter, March 1969, Avail:TAC (4p)

A description of the principles of operation of a heat pipe is given emphasizing its high efficiency. The importance of selection of working fluid and wick geometry and their influence on the operating characteristics of the heat pipe are outlined.

Heat pipe applications for thermoelectric generators and other devices are listed.

70001 APPLICABILITY OF HEAT PIPES TO ENERGY CONVERSION SYSTEMS
Sandia Corp., Albuquerque, N. Mex. Aerospace Radioisotope Power Information Center. G. H. Whiting and K. T. Feldman, Jr. (N. Mex. Univ., Albuquerque) Jun. 1969 24 p refs Sponsored by AEC. Supersedes SC-DC-67-2003. (SC-ARPIC-1012; SC-DC-67-2003) Avail:TAC

The heat pipe is a unique, high flux, heat transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to give it an effective thermal conductivity several thousand times that of copper. The major operating characteristics of a heat pipe are nearly perfect isothermal operation over lengths of several feet, thermal transformer operation where heat is added over a small area at high flux and removed over a large area at a low flux and vice versa, thermal power flattening where large variation in output heat flux cause very little variation in output heat flux. The heat pipe is ideally suited for energy supply, removal, and thermal control of energy conversion systems. Performance characteristics and possible applications to conventional and direct energy conversion systems for terrestrial and space use are discussed.

70002 THE HEAT PIPE EXPERIMENT
National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala. R. D. Shelton, 16 Sep. 1969 13 p ref (NASA-TM-X-53930; MSEC-R-SSL-INN-67-10) Avail:TAC

A system capable of achieving a constant and uniform temperature over a sizable volume was described. It is relatively immune to problems of localized heat additions and subtractions and possesses remarkable simplicity, low cost, and reliability properties, and is susceptible to simple and direct operational checks under space conditions.

70003 HEAT TRANSFER DEVICE Patent Application
Westinghouse Electric Corp., Pittsburgh, Pa. Ralph W. Kalkbrenner, inventor (to NASA) Filed 21 May 1970 13 p Sponsored by NASA. (NASA-Case-NPO-11120; US-Patent-Appl-SN-39343) Avail:TAC

A heat transfer device characterized by a hermetically sealed tubular housing including a tubular shell terminating in spaced end plates, and a tubular mesh wick concentrically arranged and supported within the housing is described. A feature of the device is an improved wicking restraint formed as an elongated and radially expanded tubular helix concentrically related to the wick. It is adapted to be axially foreshortened and radially expanded into engagement with the wick in response to an axially applied compressive load, by which the wick is continuously supported in a contiguous relationship with the internal surfaces of the shell.

70004 THE HEAT PIPE (LE CALODUC)
A. M. Shroff and M. Armand (Thomson-CSF, Orsay, Essonne, France). Revue Technique Thomson-CSF, vol. 1, Dec. 1969, p. 611-648. 29 refs. In French, Avail:TAC

Discussion of the heat pipe, which is a quasi-isothermal heat transfer device. It can be used for lengths above several tens of centimeters for various temperatures, and for heat flows of several kW/sq cm. The heat pipe consists of a metal or insulating tube the inside wall of which is lined with a grid which constitutes a capillary system. The tube contains a metallic or insulating substance which is sufficiently volatile at operating temperature so as to slightly oversaturate the capillary system. Advantage is taken of the latent heat of vaporization of the liquid, the vapor of which is transferred from the evaporator to the condenser, where the heat is recovered in the form of condensation heat, and the condensed vapor flows back to the evaporator under the effect of capillary force or gravity.

70005 HEAT PIPE: SPACE SPINOFF FOR HEAT TRANSFER
Eastman, G. Y. (Spec. Power Devices Eng., RCA, Lancaster, Pa.). Heat., Piping Air Cond. 1969, 41(12), 57-61 (Eng), Avail:TAC

A discussion is given on the principles of design and operation of heat pipes.

70006 HEAT TUBES
Moskvin, Yu V, Fillinnov, Yu N. High Temp., v 7 n 4 July-Aug 1969, p 704-13, Avail:TAC

Data on heat pipes is contained in this survey. The authors describe the operation principles, methods of preparation, choice of working fluid, operating conditions of heat pipe, limits of heating efficiency which can be experimentally realized, compatibility of materials, and problems involving the use of heat pipes. 45 refs.

71001 THE STUDY AND CLASSIFICATION OF TWO AND MULTI-COMPONENT HIGH THERMAL CONDUCTANCE DEVICES Interim Report

Purdue Univ., Lafayette, In . Heat Transfer Lab. W. O. Barsch, R. J. Schoenhals, E. R. F. Winter, and R. Viskanta, 20 Aug. 1970 263 p refs (Contract NAS8-24015) (NASA-CR-102943) Avail:TAC

A comprehensive literature review covering the period from 1964 through midyear 1970 on heat pipe technology is presented. A brief citation of early heat pipe work is followed by a presentation of heat pipe phenomenology in which the mechanism of operation, external boundary conditions, operational limits, the influence of noncondensable gases, and startup behavior are discussed. Experimental investigations directed at determining the suitability of various substances for use as working fluids and wicks are described. In addition, numerous experimental studies dealing with operational characteristics of heat pipes are evaluated. Several possible areas of heat pipe application including heat transfer, temperature control, heat flux conversion and control of thermal conductance are examined. A discussion of basic heat pipe theory together with numerous modifications and simplifications concludes the review.

71002 HEAT PIPE - A NEW HEAT TRANSFER SYSTEM (DAS WÄRMEROHR - EIN NEUES WÄRMEÜBERTRAGUNGSSYSTEM)
Helmut Neu (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). Schweizerische Technische Zeitschrift, vol. 67, Dec. 17, 1970, p. 996-1001. 6 refs. In German, Avail:TAC

Description of the principle, design, and applications of heat pipes. Different heat transfer systems are described, and their output is compared with that of a heat pipe. Liquids used for heat transfer in heat pipes over different temperature ranges are reviewed. The applications of heat pipes are discussed, including temperature homogeneization, transformation of the heat flux density, and temperature control.

B. HEAT PIPE APPLICATIONS

B.1 GENERAL APPLICATIONS

B.1-i-a

65003 ANALYSIS OF A DOUBLE FIN-TUBE FLAT CONDENSER-RADIATOR AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Henry C. Haller, Washington, NASA, Dec. 1964 45 p refs (NASA-TN-D-2558), Avail:TAC

An analytical study of a flat condenser-radiator with a double fin-tube geometry (closed sandwich) with variable tube side-wall thickness was performed for a Rankine space-power electric-generating system. The analysis of the double-fin radiator included consideration of tube and header pressure drops, meteoroid protection for the tubes and headers, along with a detailed presentation of the heat-rejection analysis and total weight characteristics. The double fin-tube radiator is compared to a conventional central fin-tube configuration on a heat rejection to weight basis for a four-panel radiator configuration. Both fin and tube geometries are compared on the basis of the same power level, working fluid temperature, tube and header pressure drop, radiator material, and meteoroid protection criteria. A beryllium radiator for a 1-MW system and a columbium alloy radiator for a 500-kW system, both at a radiating temperature of 1700° R, were chosen for the weight and geometry comparisons.

65004 ANALYSIS AND EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POWER RANKINE CYCLES
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Henry C. Haller, Seymour Lieblein, and Bruce G. Lindow, Washington, NASA, May 1965 63 p refs (NASA-TN-D-2836) Avail:TAC

An analytical investigation of a flat, direct-condensing fin-tube radiator employing segmented vapor-chamber fins as a means of improving heat rejection was performed for illustrative high-power, high-temperature Rankine space power electric generating systems. The analysis of the vapor-chamber fin-tube radiator considered pressure drop in the radiator tubes and headers, meteoroid protection for the tubes, headers, and vapor-chamber fins, and temperature drop in the tube armor in the development of the descriptive equations. The heat transfer, weight, and geometric characteristics of the vapor-chamber fin-tube radiator were determined over a wide range of variables for two illustrative radiator design applications. The vapor-chamber fin-tube radiator was also compared to the more conventional solid-conducting double fin-tube and central fin-tube radiators on a weight and geometry basis for a nonredundant configuration with a high level of nonpenetration probability. The radiator can function as a solid-conducting configuration after the vapor chambers have been punctured by meteoroids, hence, its thermal effectiveness does not decrease in direct proportion to the number of fin segments punctured.

65005 NEW METHOD FOR VAPOR-PRESSURE MEASUREMENTS AT HIGH TEMPERATURE AND HIGH PRESSURE
J. Bohdansky and H. E. J. Schins, Journal of Applied Physics, Vol. 36, No. 11, 3683-3684, Nov. 1965. Avail:TAC (2p)

The known methods for metal vapor-pressure measurements at high temperatures and high vapor pressures are troublesome and require rather complicated equipment. Not too much experimental data, therefore, has been published in the pressure range above 500 Torr and above 600°C. In this article, a method is described for measuring the vapor pressure in this region with rather simple equipment. This method is based on an observation published by Grover et al., that an inert gas is clearly separated from the metal vapor in a working "heat pipe."

67007 HIGH TEMPERATURE INORGANIC CHEMISTRY Annual Progress Report, 1 Jul 1965-31 Jul 1966
Temple Univ. Research Inst. Philadelphia, Pa., A. V. Grosse and J. A. Cahill, 15 Aug 1966 39 p refs (Contract AT(30-1)-2082) (RITU-1966-18; APR-8; NYO-2082-6) Avail:TAC

Results are reported for studies on electric conductivity of liquid tin to 2200°K, liquid bismuth to 1600°K, and liquid lead to 1800°K; use of heat pipe to measure thermal conductivity of solids and liquids by using it with centrifugally rotating liquid pipes; liquid aluminum oxide window; interaction of tungsten with liquid tin, bismuth, and lead; behavior of liquid tungsten carbide with the liquid solution of carbon in zirconium carbide; and centrifugal plasma jet apparatus.

67008 THE HEAT PIPE AND THE THERMOSIPHON FOR COOLING GAS TURBINE BLADES (LE CALODUC ET LE THERMOSIPHON POUR LE REFROIDISSEMENT DES AUBES DE TURBINES A GAZ)
Claude Moussez and Arlette Mihail (Société Nationale d'Etude et de Construction de Moteurs d'Aviation, Division Atomique, Département Etudes Thermiques, Paris, France). Entropie, Sept.-Oct. 1966, p. 102-109. 17 refs. In French. Avail:TAC

Study of methods of keeping turbine blades at a temperature level compatible with the behavior of the material of the blades. The purpose is to make possible improved turbojet performance by increasing the temperature of the combustion gases. In order to keep the blades at a safe temperature, it is suggested that cooled extensions might be fitted to the roots of the blades, thus forming a body like a tight capsule containing a molten metal of high conductivity. The isothermal nature of the system can be obtained by using the thermosiphon effect for the moving blades and the heat pipe effect for the stationary blades.

67009 SURFACE TENSION AND DENSITY OF THE LIQUID EARTH ALKALINE METALS Mg, Ca, Sr, Ba
J. Bohdansky and H. E. J. Schins, J. Inor. Nucl. Chem., 1968, Vol. 30, pp. 2331-2337.
Avail:TAC (7p)

The surface tension and the density of the liquid earth alkaline metals Mg, Ca, Sr and Ba were determined in a region of high temperature. The method used is described. Fair discrepancies in temperature dependences or absolute values or in both with regard to existing data were found. The measurements correspond to the following formulas: Mg: $\sigma=721-0.149T$ ρ=Ref. (5) confirm. Ca: $\sigma=472-0.100T$ $\rho=1.613-2.21\ 10^{-4}T$ Sr: $\sigma=392-0.085T$ $\rho=2.648-2.62\ 10^{-4}T$ Ba:$\sigma=351-0.075T$ $\rho=3.59-2.74\ 10^{-4}T$ The intersection of all surface tension lines in one point near $\sigma=0$ is interpreted as a consequence of equal surface energy per surface atom for all earth alkalines.

67010 VAPOR PRESSURE OF DIFFERENT METALS IN THE PRESSURE RANGE OF 50 TO 4000 TORR
J. Bohdansky and H. E. J. Schins, Journal of Physical Chemistry, 71, 215 (1967).
Avail:TAC (3p.)

The vapor pressure of Cs, Rb, Na, Li, Sr, Ca, Tl, Bi, Ba, Pb, and Ag was measured in the pressure range of 50 to 4000 torr. The method used for these experiments is relatively independent of impurity concentration. All measured values for the different metals follow regression lines. The constants of these lines are listed as well as the boiling points and the latent heats of vaporization. The experimental data are compared with those in the literature.

67011 THE VAPOR PRESSURE OF YTTERBIUM IN THE PRESSURE RANGE OF 40-400 TORR
J. Less-Common Metals, 13, (1967) p. 248 Avail:TAC (1p) J. Bohdansky, H. Schins.

The vapor pressure of Yb was measured in an open "heat pipe." The method which has been described by the authors recently is briefly as follows. A tube closed at one end contains the test metal and argon at a certain pressure. The tube is heated in a vertical position by a RF furnace at the lower (closed) end. The heated part, enclosing the test metal, is brought to a temperature where the vapor pressure of the metal in the tube equals the argon pressure. At this point the vapor pushes the argon in the upper part of the tube and a zone of constant temperature is established in the lower part by the metal vapor; in fact there is a sharp change over in temperature between the metal vapor part and the argon. The pressure of the argon--measured at cold conditions--and the temperature in the hot zone give the corresponding data for vapor pressure and temperature of the test metal. This method works at vapor pressures above 40 torr.

67012 THE SURFACE TENSION OF THE ALKALI METALS
J. Bohdansky and H. E. J. Schins, J. Inorg. Nucl. Chem., 1967, Vol. 29, pp. 2173-79.
Avail:TAC (7p)

The surface tension of the alkali metals has been measured at high temperature, using the maximum bubble pressure method in an open heat-pipe. The investigated temperature range was between 1200°K and 1600°K for lithium and between 700°K and 1200°K for the other metals. The experimental results are compared with existing experimental and theoretical data.

68004 PRELIMINARY EVALUATION OF GAS TURBINE REGENERATORS EMPLOYING HEAT PIPES Final Technical Report
Calvin C. Silverstein, Baltimore, Md., Apr. 1968 112 p refs, Avail:TAC (Contract DAAJ02-67-C-0053) (USAAVLABS-TR-68-10)

A preliminary study of heat pipe gas turbine regenerators for future Army aircraft power plants was carried out, and a feasibility evaluation was made. Heat pipe regenerators appear to be technically feasible, and they can readily be integrated with gas turbines with a minimum of duct pressure losses and engine modification. Regenerator weight is comparable to or greater than that of other regenerator types. Considerable development can be anticipated for both individual heat pipes and regenerator core modules prior to completion of a successful prototype. Regenerator costs are expected to be high.

68005 TOTAL HEMISPHERICAL EMISSIVITY MEASUREMENTS BY THE HEAT PIPE METHOD
Los Alamos Scientific Lab., N. Mex., J. E. Deverall, 4 Apr. 1968 10 p refs (Contract W-7405-ENG-36) (LA-3834-MS) Avail:TAC

The heat pipe appears to have great potential for determining the total hemispherical emissivities of surfaces. If a heat source is located inside a heat pipe, the heat input to the system is accurately known. All of the heat input must be radiated from the external surface of the heat pipe and if the surface is isothermal, the total emissivity can be determined. The heat pipe, with its two-phase fluid flow, has this ability to maintain isothermal conditions over large areas and provides a simple, accurate method for emissivity measurements. By using various heat pipe containers and plating or spraying the containers with different materials, the emissivities of numerous materials can be established. The total emissivities of several different surfaces have been determined over a wide temperature range using a variety of heat pipe sizes and operating fluids. The results indicate that accurate, absolute measurements can be made by this method.

68006 TWO PIECE HEAT PIPE CONVERTER
Ernst, D. M., Eastman, G. Y., 21st Annual Power Sources Conf-Proc US Army Electronics Labs., Fort Monmouth, NJ May 16-18 1967, p 135-8, Avail:TAC

Development of a light weight hydrocarbon-fueled thermionic generators intended for military field use; improved performance results from physical separation of heat source and converter by means of heat pipe; use of aluminum oxide flame barrier to prevent diffusion of combustion gases into converter and to protect emitter from oxidation.

68007 THE SURFACE TENSION OF Ag, Tl, Pb AND Bi AT HIGH TEMPERATURE
J. Inorg. Nucl. Chem., 1968, Vol. 30, pp. 3362 to 3365 Avail:TAC (5p) J. Bohdansky, H. Schins

A new method has recently been described to measure the surface tension of liquid metals at temperatures where their vapor pressure ranges from 20 to 400 torr. In this method use is made of an open heat-pipe. The application of the open heat-pipe is of especially great advantage at high temperatures where the creation of an isothermal liquid pool by other methods is rather difficult. In this note surface tension measurements on Ag, Tl, Pb and Bi in the temperature range of 1300°K (Bi)-2200°K (Ag) are reported.

68008 IMPROVED RELIABILITY OF TWT'S THROUGH USE OF NEW LIGHT-WEIGHT HEAT REMOVAL DEVICE
Basiulis, A., Starr, M. C. IEEE--Trans on Electron Devices v ED-15 n 8 Aug 68 p 613-14, Avail:TAC

It has been demonstrated that "heat pipe" cooling technique can be applied to TWT's (traveling-wave tubes); since heat pipe will reduce temperature drop and operating temperatures along vacuum barrel, improved reliability can be attained; in addition, design flexibility is increased, and overall TWT weight can be reduced.

69007 EXPERIMENTS USING A 25 KW HOLLOW CATHODE LITHIUM VAPOR MPD ARC JET
D. B. Fradkin, A. W. Blackstock, D. J. Roehling, T. F. Stratton, M. Williams (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.), and K. W. Liewer. American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 7th, Williamsburg, Va., Mar. 3-5, 1969, Paper 69-241. 16 p. 19 refs., Avail: TAC AEC-sponsored research

Description of the performance of a 25-kW, lithium fueled, applied field magnetoplasmadynamic (MPD) arc jet which incorporates a unique feed system with an open-ended heat-pipe vaporizer and a hollow cathode. The arc typically operates at currents of 250 to 500 A, voltages of 40 to 60 V, and magnetic field strengths between 500 and 3000 G, and produces a highly ionized lithium beam which transports 70% of the input electrical power to the beam stop. The ambient tank pressures range as low as 2×10^{-7} torr. A comparison of hollow-cathode and conventional MPD arc performance is made, and it is concluded that the hollow-cathode arc is superior to the conventional design. The efficiency of a process which converts input electrical power into kinetic energy is discussed in terms of a model which sets the plasma into rotation with subsequent expansion in a magnetic field.

69008 HEAT PIPE GAS TURBINE REGENERATORS
C. C. Silverstein. American Society of Mechanical Engineers, Winter Annual Meeting and Energy Systems Exposition, New York, N.Y., Dec. 1-5, 1968, Paper 68-WA/GT-7. 9 p. 9 refs., Avail:TAC Grant No. DA-AJ-02-67-C-0053

A preliminary evaluation of small aircraft gas turbine regenerators employing heat pipes as the active heat transfer elements has been carried out. The heat pipes permit the use of single ducts for the transport of the compressor discharge and turbine exhaust streams through the regenerator. This feature simplifies regenerator design and facilitates integration of the regenerator with the gas turbine. However, on the basis of weight and cost, the heat pipe regenerator does not appear to be competitive with other regenerator types at the present time.

69009 THE HEAT PIPE AND SOME POTENTIAL NAVAL APPLICATIONS
Office of Naval Research Washington, D.C., O. J. Loper, 1969, 6 p. Availability: Pub. in Naval Research Reviews, p 17-21 Aug 69. (AD-697334)

The heat pipe is a high heat conductance device that works on the principle of vapor heat transfer resulting from boiling a liquid in one end (evaporator) of a closed container--pipe or duct--and condensing in the cool end (condenser). This seemingly simple device can transfer extremely large amounts of thermal energy with a very small temperature drop. The theories of operation of the heat pipe are complex, but development has proceeded very rapidly in the past few years to the point where heat pipes can now be considered competitive for many naval applications, from the cryogenic to the 2000C temperature region.

69010 HEAT PIPES FOR TEMPERATURE CONTROL
Bienert, Walter (Dynathern Corp., Cockesville, Md.). Proc. Intersoc. Energy Convers. Eng. Conf., 4th 1969, 1033-41 (Eng). Amer. Inst. of Chem. Eng.: New York, N.Y., Avail: TAC

Several techniques for using a heat pipe to control temps. are reviewed. A detailed anal. of a self-controlled thermal control heat pipe using a non-condensing gas is presented. The model describes the variation of the heat source temp. T_8 as a function of heat flow Q and sink temp. T_0. Exptl. results are given for a pipe using MeOH and operating at 40°.

69011 CRYOPUMPING OMNITRON ULTRA-VACUUM SYSTEM USING "HEAT PIPES" AND METALLIC CONDUCTORS
Milleron, N. (Univ of Calif, Berkeley), Wolgast, R.; IEEE-Trans on Nuclear Science v NS-16 n 3 June 69, p 941-4. Avail:TAC

An omnitron is a synchrotron accelerator with concentric storage ring that will deliver beams of light and/or heavy ions in high-charge state for 25 msec requires that vacuum be specified more carefully than is common in everyday speech; cryopumping is done by cold fingers inserted in each gap between magnets on both synchrotron and storage rings; each finger, consisting of 80 K jacket around 4 K core, is cooled at one end of metallic attachment to nitrogen and helium distribution rings; pump-down tests of one full size pumping station comprising alumina beam tube brazed to stainless steel are reported using "heat pipes" (thermal siphons) and metallic heat conductors in cold finger design; superior pumping performance is achieved, i.e., pump down requires 7 hr to omnitron figure of merit; garden variety oil sealed mechanical pump and oil (convoil 20) diffusion pump provided with fail safe LN trap-valves are used.

69099 HEAT-PIPE OVEN: A NEW, WELL-DEFINED METAL VAPOR DEVICE FOR SPECTROSCOPIC MEASUREMENTS
C. R. Vidal and J. Cooper, National Bureau of Standards, Boulder, Colo., Journal of Applied Physics, Vol. 40, No. 8, p. 3370-3374, July 1969, Avail:TAC

A new, well-defined metal vapor device called the heat pipe has been developed on the basis of the heat pipe, a heat conductive element designed by Grover and his coworkers in Los Alamos. It continuously generates homogeneous vapors of well-defined temperature, pressure, and optical path length. The vapor is confined by inert gas boundaries which remove the window problem and allow a direct pressure measurement without relying on vapor pressure curves. Due to the continuous evaporation and condensation the vapor purifies itself during operation.

70007 ADVANCED RANKINE CYCLE PROVIDES BASIC TECHNOLOGY FOR OTHER POWER PLANTS AS WELL
A. J. Wilson (General Electric Co., Cincinnati, Ohio). American Institute of Chemical Engineers, Intersociety Energy Conversion Engineering Conference, 4th, Washington, D.C., Sept. 23-26, 1969, Paper 11c. 15 p. 19 refs., Avail:TAC

Review of the technology of the advanced Rankine cycle power plant as it evolved over eight years, and of how the high-temperature, refractory alloy, and liquid-metal experience gained in the technology development is applicable to that required for the nuclear Brayton cycle and thermionic power systems. A comparison of technology requirements of the advanced Rankine cycle three-loop system, the three-loop Brayton cycle system, and the two-loop reactor thermionic power plant is given. The advanced Rankine cycle technology is then reviewed to point out the present status and show the relevancy to the needs of the Brayton cycle and thermionic power plants. It is shown that for all three systems the most attractive heat source is a compact fast spectrum nuclear reactor using an alkali-metal coolant which presents one of the most prominent features of the advanced Rankine cycle technology. The most significant advantage of such nuclear reactors is the minimum reactor vessel diameter resulting in minimum shielding weight, so that it may be effectively used in space. Heat-rejection systems of all three power plants may also be most effectively designed by the employment of liquid coolants. The employment of heat pipes as radiation fins attached to the liquid-coolant ducts may be an additional attractive possibility in any of the three systems. Finally, heat exchangers with liquid metals on one or both sides, pumps, valves, structural materials fabrication techniques, and liquid metal purification and handling techniques are all common to the three power plants.

70008 DEVELOPMENT AND FEASIBILITY TESTS OF ISOTHERMAL IRRADIATORS
(CONF-690910-, pp 184-96) Weaver, C. V.; Patrick, A. J.; Ranken, W. A. (Los Alamos Scientific Lab., N. Mex.).

Laboratory and reactor tests are described which are used to show that specimen temperatures in irradiation experiments can be established and regulated through the use of inert-gas-filled heat pipes. When properly constructed, such pipes will last almost indefinitely and require no servicing. With the wide choice of available working fluids, there is no real restriction on the operating temperature of such devices other than the temperature of the reactor coolant.

70009 FINAL REPORT FOR ICICLE FEASIBILITY STUDY
Wright, P. E., prepared for Goddard Space Flight Center by Advanced Technology Labs., Camden, N.J., Avail:TAC 270p.

A feasibility study and conceptual definition of an integrated Cryogenic Isotope Cooling Engine System (ICICLE) have been completed. This investigation included a study of the possible applications of such a system and the performance requirements thus identified. The basic system configuration studied was based on a heat driven cryogenic refrigerator operated from a radioisotope heat source and thermally coupled with heat pipes.

70010 ICICLE. INTEGRATED CRYOGENIC ISOTOPE COOLING ENGINE SYSTEM
Shelpuk, B. et al., ASME Pap 70-HT/SpT-30 for meeting June 21-24, 1970. Avail:TAC 8p.

The cryogenic refrigeration requirements of future spacecraft are reviewed and a central refrigeration system providing 5 w of cooling at 75 K is described. ICICLE (Integrated Cryogenic Isotope Cooling Engine System) utilizes a low electric power Vuillemier cycle refrigerator powered by a radioisotope heat source. Thermal linkage from the VM engine to the radioisotope, to the sensors requiring cooling, and to a radiator is accomplished by means of heat pipes. A discussion of the physical principles involved with all of the system components, as well as a performance description of each, is included. The integration of the system into a typical spacecraft is discussed with projected life, performance and weight.

71003 TECHNIQUE FOR THE DIRECT MEASUREMENT OF THERMAL CONDUCTIVITY AT HIGH TEMPERATURES BY THE USE OF A HEAT PIPE
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. Ralph Forman, Oct. 1970 17 p refs (NASA-TM-X-52909) Avail:TAC

An experimental technique for accurately measuring thermal conductivity in the temperature range of 800 to 1500 C is presented. The procedure is capable of making a direct measurement of the heat flux and temperature drop across a sample by the use of a heat pipe to transport the heat flux. The technique eliminates many of the uncertainties associated with methods presently employed to measure thermal conductivity at these high temperatures. Other applications of the method are also discussed.

71004 HEAT PIPE PRINCIPLE PUT TO USE
Albach, C. R., Professional Engineer, March 1971, p. 21-23. Avail:TAC

A short review of the heat pipe development is followed by the description of a Thermal Recovery Unit (TRU) that is utilizing heat pipes. The use of the TRU in heating and air conditioning systems is suggested. The TRU consists of a number of parallel heat pipes installed in an airtight diaphragm such that one end of the heat pipes is exposed to the make-up air and the other end to the exhaust air with no cross-contamination of outgoing with incoming air. In a heating system the make-up air would be pre-heated by the warm exhaust air while in a cooling system the make-up air would be pre-cooled. The two operations take place with no physical reversal of the unit and the system requires essentially no maintenance due to the fact that it is self-contained and has no moving parts. Other possible applications are listed such as ovens, sleeping bags and the use in a climate control system in spacecrafts and in the preservation of permafrost under buildings in arctic regions.

71043 EXPERIMENTAL EVALUATION OF AN AUTOMATIC TEMPERATURE CONTROLLED HEAT PIPE
Harbaugh, W. E., Eastman, G. Y., Intersociety Energy Conversion Engrg. Conf., Boulder, Colo., Aug. 13-17, 1968.

B.2 THERMIONIC AND THERMOELECTRIC CONVERTERS

65006 THE USE OF A NEW HEAT REMOVAL SYSTEM IN SPACE THERMIONIC POWER SUPPLIES
European Atomic Energy Community, Brussels (Belgium). G. M. Grover (Los Alamos Sci. Lab.), J. Bohdansky, and C. A. Busse, Jan. 1965 10 p refs (EUR-2229.e) Avail:TAC

Structures of very high thermal conductance known as heat pipes are described. For a specific method of fabrication and for operation in gravity free conditions, a relation is derived for computing the optimum heat transfer as a function of the pipe radius, length and the physical properties of the fluid. For a pipe of one centimeter radius and fifty centimeters long, the theory predicts heat fluxes of from 3 to 95 kilowatts. Possible uses of heat pipes in space power supplies are discussed. These uses depend strongly on the lifetime and operating temperature limits.

65007 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept. W. E. Harbaugh, 30 Jun 1965 49 p, Avail:TAC (Contract AF33(615)-2617) (QTR-1; AD-468477)

This report covers the effort applied during the first three months on the subject contract toward the development of a long life insulated thermionic converter integrated with an efficient, constant temperature heat transfer device. Specifically, the cylindrical converter, RCA Type A-1198B will be adapted for heating by means of a heat pipe to operating temperatures of 1500°C. The module available from prior work was life tested for more than 1000 hours. Irreparable damage was caused by equipment failure and the test halted.

65008 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., quarterly technical rept. no. 2, Mar-Sep 65., by W. E. Harbaugh, Sep 65. 30p. Contract AF33 6152617

This report covers the development of a long life insulated thermionic converter integrated with an efficient, constant temperature heat transfer device. Specifically, the cylindrical converter is being adapted for heating by means of a heat pipe to operating temperatures of 1500°C. Progress was made in the development of high temperature ceramic-to-metal seals for use in the improved three converter module. High quality cesium was produced, using a purifying device based on heat pipe principles. The effect of xenon on thermionic converter performance was determined at an emitter temperature of 1350°C. Aluminum oxide insulated emitters were tested to 1600°C to determine the electrical and thermal resistance of the tri-layer. The heat pipe test vehicle gave satisfactory performance and produced design data used to fabricate prototype heat pipes. An 1198°C converter was fabricated for integration with the heat pipe. Electrical test indicated the need for minor modifications.

65009 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster Pa., Direct Energy Conversion Dept., quarterly technical rept. no. 3, 15 Sep-15 Dec 65, by W. E. Harbaugh, Dec 65, 35p. AFSC 2617-12

A contract objective was met during this report period when an A-1198C converter produced uniform electrical power output for a period of 506 hours when heated solely by a heat pipe. Progress was made in the improvement of the three converter module although problem areas still exist in high temperature ceramic to metal seal technology. Cesium quality was improved by the use of ultra high vacuum processing equipment. The effect of xenon and argon on converter performance was determined at emitter temperatures up to 1550°C. Tests continued on the insulating capabilities of aluminum oxide layers at 1600°C. Heat pipe processing was improved and simplified and prototype heat pipes were tested to 1600°C. Fabrication of additional A-1198C converters was continued. These converters will be used to obtain calibration test data with an electrical heater and for additional life tests.

65010 THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH THERMIONIC ENERGY CONVERTERS
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., quarterly rept. no. 2, 1 Oct-31 Dec 65, by W. B. Hall, and S. W. Kessler, May 66, 43p. Contract DA-28-043-AMC-01507(E) Proj. DA-1G622001A0530 ECOM01507-2

Work concerned the most efficient method of coupling a simulated thermionic converter to a heat pipe. The heat pipe incorporates a gas barrier and is used to conduct the heat from a fossil fuel burner to the simulated converter. A theoretical analysis of the operation of the heat pipe will be made and confirmed experimentally. Progress was made on the following tasks: the construction of a sodium heat pipe which operated to 1000 Centigrade; the evaluation of sodium as a working fluid; the evaluation of the wetting characteristics of lead on different capillary structures; the fabrication of vacuum tight ram seals and the development of a high strength alumina body for the barrier. Preliminary evaluations of the permeation characteristics of barrier materials was initiated.

65011 PROTOTYPES OF HEAT PIPE THERMIONIC CONVERTERS FOR SPACE REACTORS
Busse, C. A., Caron, R., Cappelletti, C., JNRC - Ispra Estab. International Conf. on Thermionic Electrical Power Generation, London (UK), Sept. 20-24, 1965. Also: Institution of Electrical Engineers (1965), pp. 1-6. Avail:TAC

Heat pipes have been suggested as heat removal systems in space thermionic power supplies. In one concept, heat is removed from the reactor at emitter temperature, each fuel rod consisting of a heat pipe ("emitter heat pipe") with the uranium containing fuel attached externally to the pipe. The pipe extends through the reflector, and a thermionic converter is located on the extended portion of the pipe. A second heat pipe is used to carry away the waste heat from the collector and act as radiator to dissipate this heat to space (collector heat pipe). Following this concept heat pipe thermionic converters have been built and operated with power outputs of up to 100 W, simulating the nuclear heating by RF. The experiments prove the feasibility of heat pipe thermionic converters. Their electrical power output corresponds to what is measured with normal thermionic converters, if care is taken with regard to diffusion of the heat pipe working fluids into the converter. Either the wall materials must be impervious to the working fluids, or working fluids must be chosen which are compatible with the converter operation (as Cs) or which may even have a favorable influence (e.g., Ba).

66003 OPTIMIZATION OF HEAT PIPE THERMIONIC CONVERTERS FOR SPACE POWER SUPPLIES
European Atomic Energy Community, Brussels (Belgium), C. A. Busse, 1965 20 p refs (EUR-2534.e), Avail:TAC

A relation for the electrical power output of a cylindrical heat pipe thermionic converter is derived, taking into account ohmic losses in emitter, collector and lead wire. The maximum electrical power output is determined for a given specific mass of the converter, emitter radius and lead wire length by optimizing the load voltage, the length of the emitter and the cross sections of emitter, collector and lead wire. The electrical power which can be generated with a single converter unit is limited by the tolerable specific mass and diameter of the emitter; large power outputs necessitate large specific masses and/or large diameters. The bulk properties of emitter, collector and lead wire material enter into the relation for the maximum electrical power output only as the product of electrical resistivity and mass density. The power output is higher the smaller each of these products is. The electrical power output of the converter differs from the power output of an ideal converter with zero electrical resistivities by Joule losses and shift losses. The efficiency of the converter reaches values of up to about 75% of the efficiency which would be obtained in case of no thermal losses through the lead wire and of zero electrical resistivities of emitter, collector and lead wire.

66004 THE DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., Interim Technical Report No. 1, 15 Mar.-15 Oct. 1965. 76 p refs (Contract DA-44-009-AMC-998(T)) (ERDL-998T-1; AD-629762) Avail:TAC

The report covers a seven month program to investigate components for flame fired thermionic energy conversion systems. The objective of the program is to demonstrate the feasibility of integrating a thermionic converter with a barrier layer and a heat pipe to obtain 1500 hour reliability of the assembly. A basic subassembly was designed to deliver 100 electrical watts from the thermal energy of a fossil fuel flame operating in an air environment. Twelve of these units would be used in the one kilowatt power module. Problems of heat transfer, permeation barrier integration, heat pipe processing and closure and burner temperature uniformity were encountered and substantially reduced or eliminated. The separate components were evaluated and determined to be satisfactory. It still remains to evaluate the complete assembly by life testing from a fossil fuel flame for a period up to 1500 hours.

66005 THE DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., Summary Technical Report, 15 Mar. 1965-15 Apr. 1966, 95 p refs (Contract DA-44-009-AMC-998(T)) (ERDL-998T-2; AD-634538) Avail:TAC

The report covers a program to investigate components for flame fired thermionic energy conversion systems. The objective of the program is to demonstrate the feasibility of integrating a thermionic converter with a barrier layer and a heat pipe to obtain 1500 hour reliability of the assembly. A basic subassembly was designed to deliver 100 electrical watts from the thermal energy of a fossil fuel flame operating in an air environment. Twelve of these units would be used in the one kilowatt power module. Problems of heat transfer, permeation barrier integration, heat pipe processing and closure, and burner temperature uniformity were encountered and substantially reduced or eliminated. After the separate components were evaluated and determined to be satisfactory, a fossil fuel-heated converter was assembled which delivered 100 watts of power during testing.

66006 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., quarterly technical rept. no. 4, 15 Dec 65-15 Mar 66, by W. E. Harbaugh, 31 Mar 66, 44p. Contract AF33(615)-2617 AFSC 2617-16

Considerable progress was made on the five-fold research projects of Phase I. In evaluating current design, an improved metallizing technique was developed for stronger ceramic-to-metal seals. In the area of performance improvement, cesium purification methods were investigated and positive contributions obtained. Testing and evaluation of the heat pipe continued with particular emphasis on problems inherent to the lithium working fluid. Evaluation of aluminum oxide as an emitter insulation probed into the merits of increased layer thickness. Converter-Heat Pipe Assemblies 4 and 5 received performance testing; thereby yielding valuable data; while fabrication of Converter A-1198C, No. 6, was completed and the unit readied for life testing.

66007 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster, Pa., summary technical rept. 15 Mar 65-15 Mar 66, by W. E. Harbaugh, May 66, 126p. Contract AF33(615)-2617 Proj. AF-8173 Task 817305 AFAPL TR-66-37

The effort reported covers the first phase of a program of developments leading to the integration of long life, insulated, thermionic converters with efficient, constant temperature, heat transfer devices. The report details the investigations which demonstrated reliability of thermionic modules by life test and of high temperature ceramic-to-metal seals. An improved module was designed for operation up to 1500C. Special investigations were conducted to improve performance by use of high purity cesium, the addition of inert gases, and the development of low work function collectors. High temperature insulation was developed and evaluated to 1600C. A cast ceramic was employed to electrically insulate the emitter from the heat source and still maintain high thermal conductivity. A high temperature converter, Type A-1198C was developed which operated successfully for more than 500 hours from thermal power supplied by means of a heat pipe. Extensive investigation was employed to design the heat pipe for this particular application. The program included evaluation of processing and closure techniques, the development of capillary structures and the determination of methods for supplying the thermal input. Prototype heat pipes were fabricated and tested for operation to 1500C temperature uniformity within 5 degrees over the length of the heat pipe, capability to deliver 50 w/sq cm at the converter emitter and operation for a minimum of 500 hours.

66008 THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH THERMIONIC ENERGY CONVERTERS
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., quarterly rept. no. 3, 1 Jan-31 Mar 66, by W. B. Hall, and S. W. Kessler, Jul 66, 47p. Contract DA-28-043-AMC-01507(E) Proj. DA-1G22001A0530 ECOM 01507-3

Descriptors: (*Heat transfer, *Thermionic converters), (*Pipes, Heat transfer), Design, Optimization, Performance (Engineering), Combustion products, Thermal stresses, Experimental data, Energy conversion, High-temperature research, Ceramic materials, Bismuth, Metal seals, Heat shields, Fuels, Gases.

66009 THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH THERMIONIC ENERGY CONVERTERS
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., final rept., 1 Jul 65-30 Jun 66, by W. B. Hall and S. W. Kessler, Sep 66, 118p. Contract DA-28-043-AMC-01507(E) Proj. DA-1G6-22001-A-053-0 ECOM 01507-F

Descriptors: (*Thermionic converters, *Heaters), (*Pipes, Heat), Fuels, Stresses, Lithium, Sodium compounds, Chlorides, Salts, Thermal properties, Lithium compounds, Fluorides, Aluminum compounds, Oxides, Materials, Heat transfer.

66010 EMPLOYMENT OF HEAT PIPES FOR THERMIONIC REACTORS
Ruehle, R.; Steiner, D.; Fritz, R.; Dagbjartsson, S. (Technische Hochschule, Stuttgart). Atomkernenergie, 10:399-404 (Sept.-Oct. 1965). (In German). Avail:TAC

It is shown how heat pipes can be used in thermionic reactors. For this purpose the mass per power ratio of three different systems was calculated: hollow sphere reactors with out-of-core thermionic converters cooled by heat pipes; cylindrical reactors with out-of-core thermionic converters heated and cooled by heat pipes; and radiators with heat pipes instead of cooling fins. For these systems, lower mass per power ratios are obtained with heat pipes.

66011 HEAT-PIPES AND THEIR APPLICATION FOR NUCLEAR POWER SUPPLIES IN SPACE
Neu, H. (EURATOM, Ispra, Italy). Atompraxis, 12: 220-4 (Apr.-May 1966). (In German), Avail:TAC

Heat-pipes are closed tube structures, wherein heat is transported by evaporation and condensation of liquids. The condensate flows back to the heating zone along small grooves inside the tube walls, propelled by the capillary forces. This new heat removal system also works well in gravity free space and shows very little temperature drop between the heating and cooling zone (some degrees). A review is given of the theoretical and experimental work carried out at Ispra. Possible combinations of tube material and working fluid and the physical and technological properties of heat-pipes are treated. Heat-pipes can be used for the heat supply to, and the heat removal from thermionic energy converters. A first experimental unit of this kind showed the expected properties. The advantages and disadvantages of a thermionic reactor concept for space using three different kinds of heat-pipes are discussed. The use of heat-pipes may also lead to special advantages for energy supplies with radioisotopes and thermionic converters.

66012 3 KW FLAME HEATED THERMIONIC ENERGY CONVERTER
Frysinger, G. R., Eastman, G. Y. Proc. 20th Annual Power Sources Conf. 1966. Avail: TAC (3p)

The report describes the basic components of a 3 KW (150 lb) thermionic energy converter. The basic components are: Fossil fuel burner, heat pipe-thermionic converter unit, and power conditioner. Special features of the power generator are the low noise level and the low weight, which makes the unit suitable especially for military application.

66013 NUCLEAR-THERMIONIC ENERGY CONVERTER
Leefer, B. I. NASA Proc. 20th Annual Power Source Conf. 1966. Avail:TAC (4p), 1 ref.

The paper describes development work on space auxiliary power system utilizing heat pipes to transfer the energy generated by radioisotopes to thermionic converter. Test results of heat pipe performance and converter performance are given.

67013 A STUDY OF A NUCLEAR THERMIONIC PROPULSION SYSTEM
Los Alamos Scientific Lab., N.Mex., E. W. Salmi (1967), 4 p. Presented at the Am. Inst. of Aeron. and Astronautics Meeting, New York (Contract W-7405-ENG-36) (LA-DC-8482; CONF-670111-1) Avail:TAC

A study was made of a nuclear electric space propulsion system. This study assumed that the system was composed of a thermionic reactor, "heat pipe" radiator and a Li arc jet propulsion unit. The specific weight of the entire system (unshielded) was 3.9 kg/kW jet power. Because of limited experimental evidence on fuel burn-up, the reactor operating time may be limited to 5000 hrs. This operating time is sufficient to accomplish the manned Mars mission.

67014 A STUDY OF A NUCLEAR THERMIONIC PROPULSION SYSTEM
E. W. Salmi (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 5th, New York, N.Y., Jan. 23-26, 1967, Paper 67-229. 5 p., Avail:TAC AEC-sponsored research.

A study has been made of a nuclear electric space propulsion system. This study assumed that the system was composed of a thermionic reactor, "heat pipe" radiator and a lithium arc jet propulsion unit. The specific weight of the entire system (unshielded) was 3.9 kg/kw jet power. Because of limited experimental evidence on fuel burn-up, the reactor operating time may be limited to 5000 hr. This operating time is sufficient to accomplish the manned Mars mission.

67015 REVIEW OF FOSSIL-FUEL-FIRED THERMIONIC ENERGY CONVERTERS
G. Y. Eastman, D. M. Ernst, W. B. Hall, S. W. Kessler, and R. C. Turner (Radio Corporation of America, RCA Electronic Components and Devices Div., Lancaster, Pa.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, THERMIONIC CONVERSION SPECIALIST CONFERENCE, HOUSTON, TEX., NOVEMBER 3, 4, 1966, CONFERENCE RECORD. [A67-22330 09-03] Conference sponsored by the Electron Devices Technical Professional Group of the Institute of Electrical and Electronics Engineers, New York, Institute of Electrical and Electronics Engineers, Inc., 1966, p. 121-125, Avail:TAC. Contracts No. DA-44-009-AMC-998(T); No. DA-44-009-AMC-1236(T); No. DA-28-043-AMC-01507(E).

The paper describes the advanced made in fossil-fuel-fired thermionic energy converters resulting from the use of a heat pipe to couple the converter with the heat source. Since the advent of the heat pipe, the power output of the converters has been increased from 10 to 100 watts. Improved performance results from a separation of the heat source and the converter. This separation allows for individual optimization of the regenerative swirl burner and permits the construction of a larger-sized cylindrical converter. Improved performance is also a result of the inherent characteristics of the heat pipe. The heat-flux transformation property of the heat pipe allows the converter, which requires a high heat flux for operation, to be operated from a low-heat-flux burner. The nearly isothermal property of the heat pipe contributes to a uniform emitter temperature and a reduction in the thermally induced stresses in the ceramic flame barrier. A heat pipe of two-piece construction, consisting of an alumina flame barrier and a molybdenum emitter, is also described, and the problems associated with its use are discussed, such as the need for a compatible working fluid, establishment of an effective temperature at the alumina-molybdenum braze to reduce external oxidation, and the search for high-purity, high-strength alumina flame barriers. The advantage to be gained from the use of two-piece heat pipes is that the temperature gradient necessary to transfer the power from the burner to the heat pipe is reduced. This temperature difference allows the thermionic converter to operate at a correspondingly lower source temperature.

67016 A LOOK AT NUCLEAR THERMIONIC SYSTEMS
R. E. Schreiber and E. W. Salmi (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.). American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 3rd, Washington, D.C., July 17-21, 1967, Paper 67-498. 7 p., Avail:TAC AEC-sponsored research

Discussion of the in-pile thermionic reactor, the core of which consists of an array of thermionic diodes, each containing uranium to maintain a fission reaction and achieve the emitter temperature needed for production of electricity. The in-pile thermionic reactor is said to be suitable for auxiliary power and nuclear-electric propulsion, especially if combined with the "heat pipe". Basic components such as the arc jet, heat pipe, and the thermionic cell are described, and a conceptual design of a moderated reactor is investigated.

67017 THERMIONIC CONVERTERS WITH HEAT-PIPE RADIATORS
Pierre Brosens (Thermo Electron Engineering Corp., Waltham, Mass.). IN: ADVANCES IN ENERGY CONVERSION ENGINEERING; AMERICAN SOCIETY OF MECHANICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, MIAMI BEACH, FLA., AUGUST 13-17, 1967, PAPERS. [A67-42485 24-03] New York, American Society of Mechanical Engineers, 1967. p. 181-187, Avail:TAC NASA-sponsored research

An analysis of heat-pipe dynamics is conducted to develop criteria for the design of thermionic converter heat-pipe radiators and the selection of their working fluid. The evolution of the design of a particular thermionic converter prototype is presented in order to demonstrate the progress of heat-pipe technology, and the reduction in thermionic converter weight made possible by the application of heat pipes. The first version of this prototype used conduction heat transfer in its collector-radiator structure, and, after thorough design optimization through the construction of several models, it weighed 320 g. An initial model of the heat-pipe version of the same prototype appeared to be well optimized and weighed only 78 g.

67018 OUT-OF-PILE HEAT PIPE THERMIONIC SPACE-POWER CONCEPT
Barnett, Charles S., (Univ. of California, Livermore). Trans. Amer. Nucl. Soc., 9: 338-9 (Oct.-Nov. 1966), Avail:TAC

67019 NUCLEAR REACTOR WITH THERMIONIC CONVERTER
Grover, George M.; Bohdansky, Josef; Busse, Claus A. (to U.S. Atomic Energy Commission). U.S. Patent 3,302,042. Jan. 31, 1967.

A nuclear reactor heat removal system is described comprising heat pipes having capillary linings extending into the reactor components from the exterior of the reactor and containing condensable vapors. The heat pipes can be employed as the heating means for thermionic energy converters.

67020 HEAT PIPES FOR THERMIONIC CONVERTER WITH ISOTOPIC FUEL
Semeria, R.; Schmidt, E. (CEN, Grenoble, France). pp 399-409 of Industrial Applications for Isotopic Power Generators. Paris, European Nuclear Energy Agency, 1967. (In French), Avail:TAC

Some results of the calculation of the design of a heat pipe for the emitter of the thermionic converter with 500 W(t) isotopic source were given. A sodium prototype was constructed and tested from 600 to 900°C in order to verify the satisfactory operation of the heat pipe in weightless regime. In the case of lead or silver heat pipes (1500°C) the importance of acceleration forces, which can affect the operation of the heat pipes at the time of launching, was emphasized.

67021 EURATOM'S ACTIVITY ON RADIOISOTOPE POWERED THERMOELECTRIC AND THERMIONIC GENERATORS
Gillot, R. H.; Neu, H.; van Andel, E. (EURATOM, Ispra, Italy). pp 461-82 of Industrial Applications for Isotopic Power Generators. Paris, European Nuclear Energy Agency, 1967, Avail:TAC

Design studies of generators using a thermoelectric conversion system were carried out for a 5 W(e) generator based on Pb Te thermoelectric couples, powered with a thulium-170 source. A demonstration device of a "sandwich" type (two modules of couples in series on both sides of the flat isotopic source) has been constructed and tested by electrical heating. Some studies have been made on electrode-element bonding. The heat source (in preparation) will be made of 15 small tubes filled with Tm_2O_3 pellets and pressed between metal plates. A parameter study for a 50 W(e) generator with Ge Si elements and an actinium-227 source shows that units with reduced size and weight should be producible for space application. Replacing the thermoelectric system by a thermionic converter has the advantage of a higher thermal efficiency. Parameter and design studies on radioisotope powered thermionic generators show however a rather strong decrease in the efficiency with decreased power output below 50 W(e). The importance of using a new heat transfer system, called heat pipes, for heat removal and heat flux concentration is discussed.

67022 ADVANCED CONVERTER DEVELOPMENT
Brosens, P. Thermo Electron Corp. Waltham, Mass. Thermionic Conversion Specialists Conf., Palo Alto, Calif. Oct. 1967. Avail:TAC (6p) 7 refs.

Two converter models of identical design but differing in collector material were fabricated and tested to determine the difference in converter performance obtained with rhenium and palladium collectors. The data cannot be compared directly because of important emitter temperature errors. The errors are ascribed to the difficulty of incorporating a suitable black-body hole in a hardware-type emitter structure. A thermal analysis is made with the assumption that the heat losses other than interelectrode radiation are identical for the two converters, and emitter temperature corrections are implicitly derived. Based on the corrected data, the use of palladium instead of rhenium as a collector is judged to reduce the output voltage of a thermionic converter of the present design by 0.037 volt. A third converter model with an identical emitter structure but incorporating a heat-pipe collector-radiator structure was also fabricated and tested. The heat-pipe structure was used to reduce the collector overheating at large output currents which has persisted throughout the development of the previous models. The performance obtained on this model demonstrated that the collector overheating problem has been overcome. The model operated in excess of 400 hours at full power, including twelve abrupt thermal cycles, without failure. It has a niobium collector, and using the thermal analysis described above to interpret its performance data, it is concluded that the output voltage is reduced by 0.074 volt with the use of niobium in place of rhenium as the collector material.

67023 INTEGRATE CESIUM-GRAPHITE RESERVOIR SYSTEM IN A HEAT PIPE THERMIONIC CONVERTER
Bohdansky, J., Salamon, K., van Andel, E. Direct Conversion Group, Euratom CCR, Ispra, Italy. Thermionic Conversion Specialists Conf. Palo Alto, Calif. Oct. 1967. Avail: TAC (4p) 8 refs.

A heat-pipe thermionic converter with a Cs-graphite absorption reservoir has been built and tested. The Cs-graphite lamellar compound enclosed by the collector heat-pipe is operated at collector temperature. The collector temperature can be changed by a movable radiation shield which surrounds partly the collector heat-pipe. A temperature sensitive bimetal system moves the radiation shield in such a way that in dependence of emitter temperature the optimum reservoir temperature is adjusted. Experimental results are reported and problems connected with the reservoir system are discussed.

67024 USE OF A NEW HEAT REMOVAL SYSTEM IN SPACE THERMIONIC POWER SUPPLIES
G. M. Grover (Los Alamos Sci. Lab., Los Alamos, N.Mex.), J. Bohdansky, and C. A. Busse, Avail:TAC Rept. No. EUR-2229 E. 10pp. (1965) (Eng.)

Structures of very high thermal cond. known as heat pipes are described. For a specific method of fabrication and for operation in gravity-free conditions, a relation is derived for computing the optimum heat transfer as a function of the pipe radius, length, and the phys. properties of the fluid. For a pipe of 1 cm. radius and 50 cm. long, the theory predicts heat fluxes of 3-95 kw. Possible uses of heat pipes in space power supplies are discussed. These uses depend strongly on the lifetime and operating temp. limits.

67025 TESTS ON FLAME HEATED THERMIONIC DIODE
Lazaridis, L., Pantazelos, P., 20th Annual Power Sources Conference--Proc. U S Army

Electronics Laboratories, Fort Monmouth, NJ May 24-26 1966 p. 175-77. Avail:TAC

Development of 45w gasoline-fueled thermionic diode converter with bonded shell-emitter structure; advantages of direct bonding of protective shell to emitter over configuration where emitter is separated from shell by vacuum, liquid, or gas are discussed; problems inherent in bonding SIC shell to W emitter attributed to WSI_2 formation; C interposed between SIC and W prevents WSi_2 from forming and insures adequate bond; heat pipe performance characteristics graphed; power output 100 w, W emitter, Ni collector, and operating temperature 1450 C.

67026 HEAT-PIPE THERMIONIC REACTOR CONCEPT
Pedersen, E. S., Nuclear Eng v 12 n 129 Feb 1967 p 112-14 Avail:TAC

Main components are reactor core, heat pipe, thermionic converter, secondary cooling system, and waste heat radiator; thermal power generated in reactor core is transported by heat pipes to thermionic converters located outside reactor core behind radiation shield; thermionic emitters are in direct contact with outside envelope of heat pipes and collectors are in contact with liquid metal secondary cooling system that transfers waste heat to radiator.

68009 SMALL OUT-OF-PILE THERMIONIC CONVERTER
Los Alamos Scientific Lab., N. Mex., Thurman G. Frank and Richard C. Anderson, 16 Apr. 1968, 8 p refs (Contract W-7405-ENG-36) (LA-3813) Avail:TAC

The preliminary design of a nominal 10-kW electrical space power supply is presented. The design uses heat pipes together with radiation coupling to transfer heat from a small compact reactor to a converter consisting of a large number of thermionic diodes of planar design. Heat pipes are used to concentrate and to disperse heat flux within individual diodes. Each component of the power supply is conservatively designed, and considerable improvement could be realized from additional study and a modest development program. The unshielded specific weight of the power supply is ≈95 lb/kW electrical.

68010 NUCLEAR THERMIONIC SPACE POWER SYSTEM CONCEPT EMPLOYING HEAT PIPES
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Colin A. Heath and Edward Lantz, Washington, Mar. 1968 24 p refs (NASA-TN-D-4299) Avail:TAC

A space power system employing out-of-pile thermionic diodes and using concentric heat pipes for both heating and cooling of these diodes has been examined. For an early application, the out-of-pile thermionic diode has some advantages over an in-pile system because it is removed from the reactor environment. Moreover, the heat pipe permits emitter temperatures that are not much less than the temperature of the fuel clad. Laboratory data on the performance of heat pipes has been examined and the results used to estimate reasonable performance levels for thermionic diodes which were consequently incorporated into a small, fast-spectrum nuclear reactor concept. Performance levels and system weights including shield weights, have been estimated from first order calculations. The overall system can have the advantage of the safety inherent in heat pipe redundancy and the improved performance available from components that are removed from the reactor environment.

68011 APPLICATION OF HEAT PIPES TO SNAP 29
W. B. Bienert, S. Frank, R. Hannah, and J. T. Peters (Martin Marietta Corp., Aerospace Group, Nuclear Div., Baltimore, Md.). IN: IECEC '68: INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, UNIVERSITY OF COLORADO, BOULDER, COLO., AUGUST 13-17, 1968, RECORD. VOLUME 1. [A68-42507 22-03] New York, Institute of Electrical and Electronics Engineers, Inc. (IEEE Publication 68 C 21-Energy), 1968, p. 477-486, Avail:TAC

A heat-pipe heat rejection system for the SNAP 29 radioisotope thermoelectric generator is currently under development. The system is comprised of a number of individual water heat pipes extending from the generator cold plate to the space radiator. The heat pipes are nominally 15 ft. long, have an outer diameter of 3/8 in., and a curved condenser which conforms to the vehicle circumference. Each heat pipe is capable of transporting 200 W at a nominal operating temperature of 300°F. The paper discusses the requirements prescribed for the heat pipe system and the design chosen to meet the specifications, as well as the fabrication and assembly methods being used.

68012 THERMIONIC HEAT PIPE SPACE POWER CONCEPT
Anderson, John L. (Lewis Research Center, Cleveland). Trans. Amer. Nucl. Soc., 11: 14 (June 1968). From 14th Annual Meeting of the American Nuclear Society, Toronto. See CONF-680601, Avail:TAC

68013 REACTOR CONCEPT FOR SPACE POWER EMPLOYING THERMIONIC DIODES AND PIPES
Heath, Colin A.; Lantz, Edward (National Aeronautics and Space Administration,

Cleveland, Ohio. Lewis Research Center). 1967. 15p. (NASA-TM-X-52370; CONF-670122-1). Avail:TAC From 5th Aerospace Science Meeting, New York.

A thermionic generator power system using a reactor heat source connected to external diodes by heat pipes is investigated. A concept capable of supplying up to several hundred kilowatts of electrical power is described. Experimental results from laboratory tests of both heat pipes and thermionic diodes have been used to set reasonable performance levels for thermionic diodes which are both heated and cooled by heat pipes. A reactor fueled with slab geometry fuel elements of uranium-233 nitride could provide a minimum power of 36 kW(e) limited by criticality considerations. Reactor control is effected by a combination of moderator and neutron absorbing material in a central region of the reactor. Neutronic calculations indicate that a 6% swing in reactivity is obtainable with this control system. Total mass of the reactor, thermionic diodes, radiator and reactor shield for an instrumented payload is estimated to be 300 kg.

68014 HEAT-PIPE THERMIONIC CONVERTER WITH GRAPHITE ABSORPTION CESIUM RESERVOIR WORKING AT COLLECTOR TEMPERATURE
Bohdansky, J., van Andel, E., IEEE-Thermionic Conversion Specialist Conference--Conference Rec Nov 3-4 1966 p 239-42, Avail:TAC

Test results for converters having cesium-graphite lamellar compound reservoirs and working below 1 torr; it was found that at optimum Cs pressure collector temperature can be chosen between numbers of discrete values corresponding to different Cs-graphite compositions; experimental data, describing functionability of converters and their limits are given.

68015 DEVELOPMENT OF INSULATED THERMIONIC-CONVERTER/HEAT-PIPE ASSEMBLY
Harbaugh, W., Longsderff, R. W. IEEE-Thermionic Conversion Specialist Conference--Conference Rec Nov 3-4 1966 p 139-43, Avail:TAC

Feasibility of operating high-power thermionic converter from heat pipe; heat pipe is integrated with cylindrical converter; assembly was extensively tested to determine operating characteristics and life capabilities; program included evaluation of heat-pipe processing techniques and capillary structures and determination of methods for supplying thermal input; converter designs and results of analyses and tests; converter power output in 275 w, output current 610 amp; molybdenum was used as collector and emitter material; emitter temperature was 1500 C, area 40 sq cm, converter weight 3.75 lb.

69012 INVESTIGATION OF PERFORMANCE OF AN OUT-OF-CORE THERMIONIC SPACE POWER SYSTEM
California Univ., Livermore, Lawrence Radiation Lab., William E. Loewe, 18 Mar. 1968, 24 p refs Submitted for publication. Supported by AEC (UCRL-70984; Conf-680802-5) Avail:TAC

Conceptual designs of out-of-core thermionic space power generators using heat pipes have been produced for various powers, temperatures, and constraints or parameter values. Since major impediments to in-pile thermionic systems are alleviated or eliminated in the out-of-core concepts, a competitive degree of feasibility and competitive specific masses are adequate to establish the need for emphasis on these systems in future studies and development activities. Feasibility in the six cases shown in conceptual detail appears to be limited only by lithium heat pipe feasibility and a favorable outcome of current technology development of UN, W, and Li materials in the temperature range considered. For example, one man-rated system at 300 KW(e) and 1800°K shows a specific mass of 7.9 kg/KW(e) and will accommodate an 18 m payload at a 50 m distance.

69013 CASCADED THERMOELECTRIC TEST GENERATOR, PHASE 2 Quarterly Progress Report, 1 Dec. 1968-28 Feb. 1969
Westinghouse Electric Corp., Pittsburgh, Pa., Astronuclear Lab., 28 Feb. 1969, 18 p. Prepared for JPL (Contracts NAS7-100; JPL-952196) (NASA-CR-100775; WANL-PD(DDD)-005) Avail:TAC

Primary interest during this period was on the fabrication of system components, on qualification testing of the sodium heat pipe, on emissivity tests of tantalum specimens coated with zirconia and alumina, and on the assembly of the SiGe stage to the heat pipe and subsequent delivery. This report includes a status summary of the major system components along with test results obtained where applicable.

69014 A NUCLEAR THERMIONIC SPACE POWER CONCEPT USING ROD CONTROL AND HEAT PIPES
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, John L. Anderson and Edward Lantz. Washington, May 1969, 32 p refs (NASA-TN-D-5250) Avail:TAC

A space power system using a fast spectrum nuclear reactor, out-of-pile thermionic diodes, heat pipes, and a dual central absorber rod type of reactivity control has been studied. Emphasis is placed on the neutronic aspects and general feasibility of the concept. Comparison is made between uranium-233 and uranium-235 nitride and plutonium-239 nitride fuels. In this concept heat is transferred from the reactor core to the thermionic diodes by layers of radial heat pipes stacked alternately with slabs of fuel. For this out-of-pile concept, which would supply about 130 kilowatts electric, the reactor can be considerably smaller than the equivalent reactor with in-pile diodes.

69015 ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY TASK 1. DEVELOPMENT OF HIGH VOLTAGE MODULE
Radio Corp. of America, Lancaster, Pa. Midterm Status Report, 1 May 1968-28 Feb. 1969
R. W. Longsderff, 28 Feb. 1969 51 p (Contract AT(30-1)-3979) (NYO-3979 1) Avail:TAC

The design of a heat pipe-thermionic module concept capable of output potentials as high as 28 volts was investigated. Technologies required for this module design were developed beyond the state-of-the-art. An advanced Al_2O_3 casting technique was developed for the fabrication of the key insulated tri-layer assembly. Arc suppression coatings were developed for the prevention of voltage arcs in the module due to potentials above the ionization potential of cesium. Fabrication and assembly techniques necessary for the logical development of the high voltage module concept were also investigated. Heat pipe designs capable of transferring the required thermal through-put for high voltage module concepts were also investigated.

69016 DESIGN AND FABRICATION OF ADVANCED THERMIONIC CONVERTERS Final Report
Thermo Electron Engineering Corp., Waltham, Mass., Nov. 1968 408 p refs. Prepared for JPL. (Contracts NAS7-100; JPL-951263) (NASA-CR-105322; TE4055-65-69) Avail:TAC

Task 1 centered on the iterative construction of 10 engineering models of a solar energy thermionic converter, and Table 1 describes their main features. In the last three models, the collector-radiator structure of the previous models was replaced by a heat pipe. At the culmination of the effort, the converter with a heat pipe structure had achieved close to a 70% reduction in weight; however, its performance was the same as that of typical converters with rhenium electrodes, and it did not reach the goal of 20 watts/cm^2 at 0.8 volt, 1700°C. Task II involved a generator flux analysis to determine the best number of converters to match the converter heat requirements to the available solar energy, the optimum cavity aperture size, the required adjustments of surface emissivity and absorptivity values to insure even flux distribution, and the effects of changes in emitter temperature and heat input on flux distribution within the generator. Based on this analysis a 16-converter generator, using converters with heat pipe collector-radiators, was designed in detail.

69017 ANALYSIS OF AN OUT-OF-CORE THERMIONIC SPACE POWER SYSTEM
William E. Loewe (California, University, Lawrence Radiation Laboratory, Livermore, Calif.). IEEE Transactions on Aerospace and Electronic Systems, vol. AES-5, Jan. 1969, p. 58-65. 19 refs., Avail:TAC AEC-sponsored research

Conceptual designs of out-of-core thermionic space power generators using heat pipes have been produced for various powers, temperatures, and constraints or parameter values. Since major impediments to inpile thermionic systems are alleviated or eliminated in the out-of-core concepts, a competitive degree of feasibility and competitive specific masses are adequate to establish the need for emphasis on these systems in future studies and development activities. Feasibility in the six cases shown here in conceptual detail appears to be limited only by lithium heat-pipe feasibility and a favorable outcome of current technology development of UN, W, and Li materials in the temperature range considered. For example, one man-rated system at 300 kWe and 1800 K shows a specific mass of 8 kg/kWe and will accommodate an 18-m payload at a 50-m distance.

69018 HEAT PIPE STUDIES AT THERMO ELECTRON CORPORATION
D. M. Ernst, E. K. Levy, and P. K. Shefsiek (Thermo Electron Corp., Waltham, Mass.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL THERMIONIC CONVERSION SPECIALIST CONFERENCE, 7TH, FRAMINGHAM, MASS., OCTOBER 21-23, 1968, CONFERENCE RECORD. [A69-21806 09-03] New York, Institute of Electrical and Electronics Engineers, Inc., 1968, p. 254-257, Avail:TAC

The paper describes three studies concerned with the development of heat pipes for use with thermionic energy conversion devices. These investigations are concentrated in the areas of wick development, high temperature heat pipe life testing, and performance testing of relatively low temperature heat pipes. The results of tests with lithium heat pipes operating at 1550°C and 2500 W are given. Extended life test data for a TZM-lithium device are presented. In addition, a new high temperature distillation method used successfully with the lithium heat pipes is described. A program to develop rigid porous tubes for use as capillary structures in heat pipes and the resulting capillary pore size data from several samples are presented.

69019 AN IMPROVED OUT-OF-CORE THERMIONIC REACTOR FOR LOW POWER
S. Dagbjartsson, M. Groll, O. Schlörb, and R. Pruschek (Stuttgart, Technische Universität, Institut für Kernenergetik, Stuttgart, West Germany). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL THERMIONIC CONVERSION SPECIALIST CONFERENCE, 7TH, FRAMINGHAM, MASS., OCTOBER 21-23, 1968, CONFERENCE RECORD. [A69-21806 09-03] New York, Institute of Electrical and Electronics Engineers, Inc., 1968, p. 299-304, Avail:TAC

Description of an out-of-core reactor whose power output and specific power are increased by using a central heat pipe in a coaxial cavity of the core. By this means, the maximum temperature does not occur at the centerline of the core but somewhere between the cavity wall and the outer surface. Therefore, at a given maximum temperature, the heat flux at the outer surface is increased. The specific power of 20 to 30 W/kg is in the same order as for a thermal incore reactor in the low-power range. The out-of-core type with a central heat pipe might be an interesting power supply in the low 10 kW_e power range and for long-time missions.

69020 A HEAT PIPE THERMIONIC REACTOR CONCEPT
P. Fiebelmann, H. Neu, and C. Rinaldini (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03] Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 243-259; Discussion, H. Unger, R. Pruscheck (Stuttgart, Technische Universität, Stuttgart, West Germany), Griaznov, and N. S. Rasor, p. 261, 262. 25 refs Avail:TAC

Introduction of an out-of-core thermionic reactor concept for space power supply in the range of 30 to 40 kWe using lithium heat pipes in crossed layers, each heat pipe bearing one converter. The concept is based on the assumption of a successful development of high temperature heat pipes (1500 to 1600°C) and related converted systems for long period operation. The converters are located outside the beryllium reflector on four sides of a nearly cube-shaped fast reactor core. Heat is transported from the (UZr) carbide fuel to the heat pipes by thermal heat radiation, thus eliminating high temperature compatibility and electrical insulation problems. The crossed layer arrangement combined with radiative heat transfer allows a simple core structure with a highly reliable cooling system using the redundancy principle. Four movable reflector segments on the top side serve for reactor start-up and power control.

69021 OUT-OF-CORE THERMIONIC SPACE POWER
William E. Loewe (California, University, Lawrence Radiation Laboratory, Livermore, Calif.). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03] Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 263-272. 22 refs. AEC-sponsored research, Avail:TAC

Survey of conceptual out-of-core thermionic systems using heat pipes identifies critical technology areas, investigates feasibility for space application, locates parameter regimes of interest, and estimates specific mass values. Required, current, and the projected state-of-the-art in these critical areas of technology are compared. Temperatures and powers were surveyed in the ranges from 1400 to 2200 K and from 10 kWe to 10 MWe, respectively. A cylindrically symmetric geometry with a linear display of system components was studied. In general, out-of-core thermionic systems with heat pipes appear to be attractive candidates for use in space over a broad range of electric power levels, meeting the requirements of both advanced auxiliary power and nuclear (electric) propulsion.

69022 DESIGN AND CHARACTERISTICS OF AN ACTINIUM FUELED THERMIONIC GENERATOR
A. De Troyer, E. Nève de Mévergnies (Union Minière, Brussels, Belgium), M. J. Brabers, P. Dejonghe (Centre d'Etude de l'Energie Nucléaire, Mol-Donk, Belgium), G. Gammel, F. Gross, M. F. Koskinen, and R. Langpape (Brown, Boveri et Cie. AG, Heidelberg, West Germany). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03] Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 305-335; Discussion, Peter Rouklove (California Institute of Technology, Pasadena, Calif.), p. 336. 9 refs., Avail:TAC

The thermionic generator to be built in cooperation between U.M. and B.B.C. is presented. Design and optimization of a thermionic generator as it stands now is given. Experimental results of measurements with a plane parallel diode using a polycrystalline tungsten emitter and a molybdenum collector at emitter temperatures between 1800 and 1900 K will be discussed. The compatibility of systems containing the following elements or compounds have been considered: La_2O_3, PbO, Pb, ThO_2, Th, W, O_2, He. The experiments are carried out at temperatures up to 2500 K. Tests up to 2000 hr are conducted at 2100 K. The permeability of ThO_2-coatings for helium has been tested on boron-containing spheres. Helium release is measured by heating the particles and collecting the gas. The metal ceramic seal has been developed, tested for about 5000 hr at 1000 K and 20 torr cesium pressure; it is still leak tight. A Nb 1% Zr collector heat pipe filled with sodium is running for about 12,000 hr. at 1100 K without degradation. The emitter lead has been proven to withstand temperature cycles between 750 and 2200 K.

69023 ADVANCES IN HEAT PIPE TECHNOLOGY
G. M. Grover, J. E. Kemme, and E. S. Keddy (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03] Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 477-490; Discussion, p. 491-494. 6 refs., Avail:TAC AEC-sponsored research

Review of recent work on materials compatibility and the maximum heat-flux capability of heat pipes. Special emphasis is placed on the heat-pipe problems associated with thermionic conversion and with the state-of-the-art relative to this field. Experimental results on operational limiting factors such as sonic flow and liquid entrainment are given. The results of an orbital flight test of a water heat pipe confirm the operability of heat pipes in a zero-g environment.

69024 CALORIMETRIC MEASUREMENTS WITH A HEAT PIPE THERMIONIC CONVERTER
J. Bohdansky and E. van Andel (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03] Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 989-996; Discussion, B. Saggau (Stuttgart, Technische Universität, Stuttgart, West Germany), p. 997. 5 refs., Avail:TAC

Description of a planar diode constructed with a central collector tube surrounded by an annular guard ring heat pipe. Both pipes are operated at equal temperature, established by an inert gas layer of equal pressure, to avoid any losses of heat energy from the central tube. Measurements were performed at 1800 K emitter temperature and different spacings and collector temperatures. These experiments allow an experimental definition of generated electrical power density and of the electrode efficiency. Both values are important for practical converter design. The most significant result of the measurements is the behavior of the heat production at the collector as a function of cell current.

69025 HEAT PIPE THERMIONIC CONVERTER RESEARCH IN EUROPE
C. A. Busse (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03) Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 861-872. 47 refs.

Review of work performed in West European laboratories, with emphasis on (1) the amount of heat that can be transported with a heat pipe, (2) the maximum heating rate, and (3) the lifetime of a heat pipe. The review also deals with thermionic energy conversion devices making use of heat pipes for heating emitters and cooling collectors.

69026 HEAT PIPE DEVELOPMENT FOR THERMIONIC APPLICATIONS
P. K. Shefsiek and D. M. Ernst (Thermo Electron Corp., Waltham, Mass.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03) Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 879-887. 10 refs., Avail:TAC Contract No. DA-36-039-SC-87341(E)

Discussion of heat pipe development specifically oriented for applications to thermionic conversion devices and related systems. High temperature lithium heat pipes for emitter applications and low temperature sodium and potassium heat pipes for collector applications have been investigated. Test results are presented for the following heat pipes: (1) unalloyed tungsten-lithium; (2) TZM-lithium at 1560 deg C; (3) nickel-sodium and nickel-potassium at 500 to 550 deg C. The results of a metallurgical examination of the TZM-lithium heat pipe are given. The heat transfer capability of the nickel-sodium, the nickel-potassium, and the tungsten-lithium heat pipes is discussed with respect to analytical predictions.

69027 POWER FROM THERMIONIC CONVERTERS
Bohdansky, J. (EURATOM-CCR, Ispra, Italy). Atomwirtschaft, 13: 548-9 (Nov. 1968). (In German), Avail:TAC

Papers presented at the International Conference on Production of Electrical Energy with Thermionic Converters, May 27 to 31, 1968, in Stresa are summarized. Converter fuel element development for ground-based reactors and heat pipe development for thermionic space reactors are emphasized.

69028 THERMIONIC CONVERTER DEVICE
G. M. Grover, C. A. Busse, R. J. Coron; US Atomic Energy Comm. Patent USA 3441752, 23 Oct. 1965; publ. 29 April 1969; prior. 14 Dec 1964, Germany e28353.

The converter comprises an emitter, a collector, a first heat pipe for transferring heat from a source to the emitter surface, a second heat pipe for transferring heat from the collector surface to a heat sink, tubular means for introducing an easily ionizable gas into the space between the emitter and collector and means enclosing the aforementioned elements.

69029 DEVELOPMENT OF THREE CONVERTER HEAT PIPE--THERMIONIC MODULE
Longsderff, R. W., Eastman, G., Harbaugh, W., IEEE-Trans on Electron Devices v ED-16 n 2 Feb 1969 p. 259 (25-4). Avail:TAC

Summary of paper presented at IEEE International Electron Devices Meeting in Washington, DC, Oct 23-25, 1968.

70011 A DESIGN STUDY OF A 350 kWe OUT-OF-CORE NUCLEAR THERMIONIC CONVERTER SYSTEM
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Roland Breitwieser and Edward Lantz, 1970, 15 p, refs. Proposed for presentation at 5th Intersoc. Energy Conversion Eng. Conf., Las Vegas, Nev., 21-24 Sept. 1970; sponsored by AIAA (NASA-TM-X-52846) Avail:TAC

Nuclear thermionic systems with the thermionic converters outside the reactor have been reexamined in the perspective of several recent technical advances; new high temperature, corrosion resistant, high strength alloys; high heat flux heat pipes; improved thermionic converters; and lightweight, vapor-cooled radiators. These have been combined to yield a new look to the out-of-core approach. A compact reactor results; insulators are eliminated by the use of heat pipes as electrically resistive elements; and weights are reduced by combining vapor-cooled radiators, structural supports, and current leads into vapor-cooled radiator modules. The overall design is also highly modular and thus provides high reliability and a reduction in development costs.

70012 A PARAMETRIC ANALYSIS OF A DEEP SEA RADIOISOTOPIC THERMOELECTRIC GENERATOR EMPLOYING A HEAT PIPE
Naval Postgraduate School, Monterey, Calif., Benjamin James Ewers, Jr. (M.S. Thesis) Jun. 1969 69 p refs (AD-704790) Avail:TAC

A parametric design analysis was performed using a heat pipe in an existing deep sea Radioisotopic Thermoelectric Generator (SNAP-21). Heat is transferred from an annular fuel pellet to an annular thermoelectric generator through a connecting heat pipe. The fuel pellet is fully shielded so that the thermoelectric generator is easily removable. Overall efficiency and the weight of major components were determined for varying fuel radii of from 1.3 to 1.7 inches and for varying insulation thicknesses of from 1.0 inch to 2.0 inch. The analysis indicates that there is a particular fuel radius (at constant insulation thickness) at which minimum weight is reached, while the maximum overall efficiency is obtained at a larger fuel radius. The median design has an overall efficiency (at the beginning of life) of 5.4% and a total weight of 570 lbs. These design results, when compared to the existing SNAP-21 design gives an increase in overall efficiency of at least 7% and a reduction in total weight of 12%.

70013 ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY. TASK 1: DEVELOPMENT OF HIGH VOLTAGE MODULE Final Technical Report, 1 May 1968-30 Sep. 1969
Radio Corp. of America, Lancaster, Pa., R. W. Longsderff, 30 Sep. 1969, 47 p, refs. (Contract AT(30-1)3979) (NYO-3979-3) Avail:TAC

The design of a heat pipe-thermionic module concept capable of output potentials as high as 28 volts has been investigated. Technologies required for this module design have been developed beyond the state-of-the-art. An advanced Al_2O_3 casting technique was developed for the fabrication of the key insulated tri-layer assembly. Arc suppression coatings have been developed for the prevention of voltage arcs in the module due to potentials above the ionization potential of cesium. Fabrication and assembly techniques necessary for the logical development of the high voltage module concept have also been investigated. Heat pipe designs capable of transferring the required thermal throughput for high voltage module concepts have also been investigated.

70014 THERMALLY CASCADED THERMOELECTRIC GENERATOR
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Patent Application, Robert Flaherty, inventor (to NASA). Filed 24 Jul. 1969 22 p (Contract NAS7-100) (NASA-Case-NPO-10753; US Patent Appl SN-844355) Avail:TAC

A thermally cascaded thermoelectric generator is disclosed. The generator includes a first stage containing high-temperature thermoelectric elements and a second stage containing lower temperature thermoelectric elements. The stages are connected in thermal series by means of an elongated heat transfer pipe containing a liquid metal and a wick. A portion of the heat radiated to the first stage from a high-temperature radioisotope source is converted to electricity. The heat rejected by the first stage is conducted to the heat pipe and absorbed by the liquid metal as latent heat of vaporization. The vapor rises to the second stage and condenses to give up latent heat of condensation which is transferred to the second stage and is converted to electricity therein. The condensed liquid returns on the wick to the vicinity of the first stage.

70015 THERMIONIC CONVERTER ASSEMBLIES
Levedahl, William John (to Martin Marietta Corp.). British Patent 1,182,799. 4 Mar 1970. Priority date 7 Nov 1966, United States.

A radioisotope-powered thermionic converter is designed with the collector-radiator structure functioning as a heat pipe for maximum efficiency in waste heat rejection. The heat pipe has a radiator configuration involving an enclosure of spaced heat-rejecting and -receiving surfaces. Several alternate designs are shown.

70016 SPACE ELECTRIC POWER R AND D PROGRAM
Quarterly Status Report for the Period Ending April 30, 1970. Part I. (Los Alamos Scientific Lab., N. Mex.). May 1970. Contract W-7405-eng-36 (LA-4446), 6p, Avail:TAC

Development and testing of a thermoelectric module for direct conversion of heat to electricity is reported. Information is included on potassium-input heat pipe, heat-pipe radiator system development, mercury radiator heat pipe, phenyl ether radiator heat pipes, and mercury input heat pipes.

70017 ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY. TOPICAL REPORT, TASK II. DEVELOPMENT OF ADSORPTION RESERVOIR
Freggens, R. A. (RCA Corp. (NYO-3979-4), Lancaster, Pa.). Period of Performance, March 1, 1969-September 30, 1969. Contract AT(30-1)3979. 48p. Avail:TAC

Work performed on the development of an integral adsorption reservoir thermionic converter is described. Three general areas were investigated during the study including cesium purification, material processing, and integral reservoir converter fabrication. The cesium purification employed a high temperature reaction to remove halide compounds. A study was also made to develop a large surface to volume ratio in a molybdenum matrix. Variations in time, temperature, and atmosphere for sintering the matrix were used as the basis of the study. The RCA A-1279 Thermionic Converter was modified to include an integral matrix reservoir and designated the RCA A-1345. The modified design included 80 cm^3 of reservoir matrix integrally located within the converter. The device was fabricated, processed, and electrically life tested using its own internal cesium reservoir for a period of 380 hours before the heat pipe-heat source failed forcing termination of the test. Long term changes in electrical output were observed after installation of each new heat source which confirmed the slowly changing nature of internal cesium equilibrium. The ability of the converter to operate successfully and stabilize at a new satisfactory level of performance after each thermal cycle validates the fundamental design.

70018 GASEOUS-CORE REACTOR CONCEPT FOR ELECTRICAL POWER GENERATION
Gritton, E. C. (Rand Corp, Santa Monica, Calif) Pinkel, B; Nuclear Applications and Technology, v 8 n 4 Apr 1970 p 355-70 Avail:TAC

Feasibility of the application of the gaseous-core reactor to electric power generation systems. An analysis of the variation-heat-transfer process in the gaseous core is presented. The results of this analysis are then combined with an estimate of the quantity of uranium required for criticality to determine the core temperature and pressure for various values of power generation and core diameters. This analysis indicated that attractive power levels in reactors of practical size can be obtained with gas pressures and wall temperatures within the potential capability of known structural materials. As an example, it is estimated that a spherical gaseous-core reactor with a radius of 152.4 cm would generate about 4000 Mw(th) with a gas pressure of about 11 atm. Several configurations of the gaseous-core reactor employing thermionic converters and heat pipes are described.

70019 THERMOELECTRIC-BIOMEDICAL HEAT PIPES
Kuo, S. C. Y. (Drexel Inst of Technol, Philadelphia, Pa.); Proc 8th Int Conf on Med & Biol Eng & 22nd Annu Conf on Eng in Med & Biol, Chicago, Ill, July 20-25, 1969 Session 13-10, 1 p. Avail:TAC

A thermoelectric-biomedical heat pipe for hypo- and hyperthermia applications which consists of a thermoelectric convertor and a slender flexible heat pipe is described.

71005 USE OF HEAT PIPES FOR ELECTRICAL ISOLATION
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Roland Breitwieser, 29 Oct 1970. 8 p refs. Presented at the Thermionic Conversion Specialist Conf., Miami, Fla., 26-29 Oct. 1970; sponsored by Inst. of Elec. and Electron. Engr. (NASA-TM-X-52928; E-6059) Avail:TAC

Some of the problems of electrical isolation of the emitter from the heat source in out-of-core thermionics can be circumvented by the use of long heat pipes as electrical resistive elements. The various relations governing electrical resistance, heat pipe geometry, heat pipe pumping limits, and temperature losses were used to estimate the performance of heat pipes used in this manner. The design variables are the form of the electrical network, heat pipe length, heat pipe diameter, wall thickness, the wick design in the adiabatic section of the pipe, and heat pipe materials. First order calculations project the attainment of 28 volts with small penalties in system performance.

71006 FABRICATION AND EVALUATION OF AN OUT-OF-CORE THERMIONIC CONVERTER MODULE
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Erich W. Kroeger, 29 Oct. 1970, 8 p refs. Presented at the Thermionic Conversion Specialists Conf., Miami, Fla., 26-29 Oct. 1970; Sponsored by Inst. of Elec. and Electron. Engr. (NASA-TM-X-52934; E-6066) Avail:TAC

The mechanical design, fabrication procedure, and preliminary test results obtained for an out-of-core thermionic converter module, heated and cooled by heat pipes are presented. The mechanical and thermal evaluation of critical module components, including the cermet insulator, converter end structure, and collector heat pipe in the form of a vapor fin radiator, is also discussed.

71007 A DESIGN OPTIMIZATION OF AN OUT-OF-CORE THERMIONIC CONVERTER
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Richard M. Williams, 29 Oct. 1970, 6 p, refs. Presented at the Thermionic Conversion Specialists Conf., Miami, Fla., 26-29 Oct. 1970; Sponsored by Inst. of Elec. and Electron. Engr. (NASA-TM-X-52930; E-6061) Avail:TAC

The module is a cylindrical converter, heated and cooled by heat pipes with an integral finned radiator. Performance data illustrating the dependence of electrode efficiency and power density on emitter and collector temperature are used as input data. Design parameters such as electrode thickness and area, and current voltage operating points are varied, and the minimum specific weight is determined. For fixed converter designs, the sensitivity of performance to changes in heat pipe vapor temperature, electrical load, and radiator area is also explored.

71008 HEAT PIPE THERMIONIC DIODE POWER SYSTEM Patent
National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala., Ambrose W. Byrd, inventor (to NASA). Issued 28 Apr. 1970. (Filed 6 Sep. 1967), 5 p, Cl. 310-4; Int. Cl. H01j. (NASA-Case-XMF-05843; US Patent 3,509,386; US Patent Appl SN-666553) Avail:TAC

A power system utilizing a number of thermionic plasma diodes in parallel and heat pipes as cathodes is described. The diodes each contain a cathode which is integral to the heat pipe and which is heated by an isotopic heat source through the heat transfer function of the heat pipe. The system employs a circulatory cooling system, with a liquid metal as the coolant.

71009 HEAT FLOW MEASUREMENTS IN A THERMIONIC CONVERTER
J. Bohdansky (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). In: Institute of Electrical and Electronics Engineers, Annual Thermionic Conversion Specialist Conference, 8th, Carmel, Calif., October 21-23, 1969, Conference Record. (A71-12201 02-03). New York, Institute of Electrical and Electronics Engineers, Inc., 1969, p. 517-520. 6 refs., Avail:TAC

Precise heat balance measurements were performed at the collector of a heat pipe thermionic converter in order to test current converter theories. Good qualitative agreement has been found between the theoretical and experimental values for heat generation at the collector. A detailed discussion based on a theoretical relation for the electron temperature in the plasma made possible also the calculation of the ion production coefficient from measured data. Comparison with the theoretical values of this coefficient gave good agreement between measured and calculated effective ionization potential, but showed a discrepancy in the effective ionization cross section.

71039 RADIOISOTOPE THERMOELECTRIC GENERATOR EMPLOYS HEAT PIPE
Westinghouse Engg, May 69, Avail:TAC (1p)

A high power (120 watts) radioisotope generator employing a heat pipe is described. The device can be operated in extreme environments and can resist acceleration forces up to 10000 g.

B.3 AEROSPACE ORIENTED APPLICATIONS

65012 SATELLITE HEAT PIPE
Los Alamos Scientific Lab., N. Mex., J. E. Deverall and J. E. Kemme, 29 Apr 1965, 23 p. refs., Avail:TAC (Contract W-7405-ENG-36) (LA-3278-MS)

A heat pipe was developed which will be used in a satellite to transfer heat isothermally from an externally mounted radioisotope to the electronic component section. The purpose of this system is to reduce the amplitude of temperature cycling of the components when in orbit. The heat pipe is stainless steel with water as the working fluid. Heat from the isotope capsule is transferred to the pipe through an aluminum block assembly. Stainless steel clamps hold the capsule in position and supply the necessary pressure for good thermal contact. This arrangement provides for simple removal of the isotope for shipping. Several test models were built and tested using electric heaters to simulate the isotope heating. A satisfactory design was developed which will transfer more than 90% of the isotope heat to the required zone.

66014 TECHNOLOGY STUDY OF PASSIVE CONTROL OF HUMIDITY IN SPACE SUITS
Northrop Corp., Hawthorne, Calif., Space Labs., Arnold P. Shlosinger, Wilton Woo, Constantino Cafaro, and Emil W. Bentilla, Sept. 1965, 79 p refs., Avail:TAC (Contract NAS2-2102) (NASA-CR-69098; NSL-65-87-3)

Two basic techniques for passive humidity control are discussed: (1) condensation of water vapor from a stagnant pressurization gas in the space suit on wicks cooled below the required dew point, and retention or transport of the liquid condensate by wicks; and (2) adsorption of the water vapor by desiccants. An analytical study is also presented of molecular diffusion, mass transfer within an adsorption bed, and condensation on a cooled wick. Tests on several wick materials indicated that wicks of glass fiber and Refrasil provide superior performance for space suit passive humidity control applications; this applies to water transport capability in a horizontal plane (simulated zero G) as well as to vertical water lift capability. Experimental findings confirmed that the applicability of desiccants is limited by high weight penalty and by difficult regeneration procedures. However, desiccants may be useful in specific applications where the advantage of operation at temperatures higher than the required dew point is significant. The feasibility of using heat sinks of organic material with suitable melt point to provide sensible heat control for periods of 30 minutes to one hour was also demonstrated.

66015 HEAT TRANSFER OF A HEAT PIPE OPERATING AT EMITTER TEMPERATURES
J. Bohdansky and H. E. J. Schins (EURATOM and Comitato Nazionale per l'Energia Nucleare, Joint Nuclear Research Center, Ispra, Italy). IN: EUROPEAN NUCLEAR ENERGY AGENCY AND INSTITUTION OF ELECTRICAL ENGINEERS, INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, LONDON, ENGLAND, SEPTEMBER 20-25, 1965. [A66-15532 05-03], 1965. 5 p. 5 refs., Avail:TAC

Experimental investigation of the usefulness of heat pipes as heat removal systems in space thermionic power supplies. The assumptions made concerning the physical working conditions of the capillary structure and mass flow were checked, and the results of experiments conducted in the temperature range from 1500 to 1900°K are discussed. Relatively good agreement was found between the calculated and measured heat flow. The deviations are possibly caused by lack of exact data for the surface tension and viscosity of the working fluids. The transition from laminar to turbulent flow in the vapor phase was measured at a Re number of about 1500. It is noted that because laminar mass flow is always higher than turbulent mass flow (with equal pressure drop along the pipe), lower Re numbers should be preferred. It is shown that this is more easily achieved with liquids having a high latent heat of vaporization. Other physical parameters such as viscosity and surface tension are of equal importance in making the proper choice of a working fluid.

66016 APPLICATION OF HEAT PIPES TO THE SNAP-19 HEAT REJECTION SYSTEM
Martin Marietta Corp., Martin Co., Baltimore Division, Baltimore, Md., 21203 (MND-5181, Oct. 1966) Avail:TAC (36p), 5 refs.

The objective of the proposed program is to develop for the SNAP-19 generator a heat rejecting fin which uses heat pipes to eliminate the temperature gradient across the fin width. It is shown that, with the establishment of a uniform temperature on the fins, it will be possible to either make the generator smaller in diameter by about 4 in. or to lower the hot junction temperature by about 40°F, while still producing the same power output. Included are a conceptual design of a heat pipe fin assembly and a program plan for developing the desired hardware.

67027 ISOTOPES AND ISOTOPE THERMOELECTRIC GENERATORS
National Aeronautics and Space Administration, Washington, D.C., Fred Schulman. In NASA. Lewis Res. Center Space Power Systems Advanced Technol. Conf., 1966, p 73-93 refs. (See N67-10261 01-03), Avail:TAC

Isotope properties, thermoelectric conversion, thermoelectric generators, and missions which illustrate the possibilities of using isotope power systems are discussed. Advantages and disadvantages of isotopic power are tabulated, and a brief history of isotopic-power generator development is presented. The figures of merit for lead telluride materials and silicon-germanium alloys as a function of temperature are compared. The combination of heat pipes with thermionic converters is described as a means of improving conversion efficiency in low-power generators. The heat pipe is an excellent thermal control device that can transfer heat from the isotope heat source to the cathode of a converter. Nimbus B mission employing two SNAP-19 generators and the SNAP-27 generator, which will provide power for scientific experiments in the Apollo lunar surface package, are mentioned to illustrate the use of isotopic power. The availability of isotopes, their production, and their cost are briefly considered.

67028 NOTES ON HEAT PIPES AND VAPOR CHAMBERS AND THEIR APPLICATION TO THERMAL CONTROL OF SPACECRAFT
National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va., S. Katzoff In Sandia Corp. Proc. of Joint AEC/Sandia Lab. Heat Pipe Conf., Vol. 1, Oct. 1966, p. 69-89. refs. (See N67-26796 14-33), Avail:TAC

Reviewed are studies concerning heat pipes and vapor chambers that were made relative to design studies of large orbiting telescopes. Discussed are studies focusing on: (1) The use of heat pipes to improve the temperature uniformity of the skin around a large cylindrical spacecraft. (2) The use of a small tube, or artery, to convey the liquid over long distances instead of depending on the wick proper. (3) Means of metallically bonding a screen wick to a wall in order to minimize the temperature difference between the wall and the liquid surface. (4) The relation of screen dimensions and construction to the suction available with it. (5) The general problem of verifying the operation of a heat tube or vapor chamber by means of tests in the laboratory 1-g environment. Also cited are areas where further developments would be useful.

67029 SPACECRAFT POWER
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. In its Space Programs Sum. No. 37-45, Vol. IV, 30 Jun. 1967, p 22-41, refs., Avail:TAC

An overview is presented on the several photovoltaic evaluation systems being used to measure the electrical characteristics of solar cells. These include the tungsten light source for illuminating test specimens at a color temperature of 2800°K; a small simulator for evaluating individual silicon solar cells at intensity levels of one solar constant or less; and a very flexible solar simulator light source, using a 19-lens lenticular system to filter a 2.5 kW xenon source in such a way that the resultant spectral distribution is essentially that of sunlight. Also discussed is the program for developing the necessary technology to achieve a power density of 20 W/lb for a folding, modular solar array having a deployed area of 1250 ft^2. Converter and generator developments for thermionic energy conversion systems are discussed, and parametric test results and performance data are depicted. Attention is focused on a high thermal conductance heat pipe device for solving the problems of heat transfer and distribution.

67030 ORBITAL HEAT PIPE EXPERIMENT
Los Alamos Scientific Lab., N. Mex., J. E. Deverall, E. W. Salmi, and R. J. Knapp (Lockheed Miss. and Space Co., Sunnyvale, Calif.), 22 Jun 1967, 14 p., refs., Avail: TAC (Contract W-7405-ENG-36) (LA-3714)

The "Grover Heat Pipe" is a self-contained, thermal conductance device which has no moving parts, utilizes the heat being transferred for its operation, has a thermal conductance higher than any known material, and conducts heat with essentially no temperature difference. Heat is transferred by means of mass flow of a fluid utilizing the latent heat of a two-phase system. The proper functioning of a heat pipe in a zero gravity field is described. A water heat pipe, 12-in. long and 3/4-in. OD, was operated in an earth orbit and its performance monitored by telemetry at several tracking stations during 14 revolutions. Results indicate that there was no degradation of heat pipe performance in a zero gravity field as compared to the performance in laboratory tests.

67031 HEAT PIPE RADIATOR FOR A 50-MWt SPACE POWER PLANT
Werner, Richard W.; Carlson, Gustav A. (California Univ., Livermore. Lawrence Radiation Lab.). June 30, 1967. Contract W-7405-eng-48. (UCRL-50294). 38p. Avail:TAC

The concept and design of a heat pipe radiator suitable for high power levels of approximately 50 MW(t) are discussed. Design considerations include meteoroid protection, heat transfer, stress, fluid flow, pressure drop, etc. A representative heat pipe design is shown to reject 46 MW at 1100°K using a total mass of 13,220 kg for a specific weight of 1.322 kg/kW(e). The radiator is used as part of a Rankine-cycle nuclear reactor power plant suitable for a manned Mars mission of 10,000 hours.

67032 FABRICATION AND TEST OF AN ALUMINUM HEAT PIPE
N. P. Jeffries, Space Power and Propulsion Section, Missile and Space Division. General Electric Company, Cincinnati, Ohio 45215. Memorandum Rept. HC-7, Feb. 67. Avail: TAC (37p)

Description of the fabrication and testing of an aluminum heat pipe. Its heat-carrying capacity as a function of temperature drop along the pipe was determined. The working fluid was water at temperatures in the range of 200 to 375°F; the heat load was from 0 to 200 watts. Included are the testing results and appendices on specifications and maximum operating times.

68016 STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS FOR ADVANCED SPACE SUITS
TRW Systems Group, Redondo Beach, Calif., Interim Report, 1 Jul. 1966-1 Sep. 1967, Arnold P. Shlosinger, Sept. 1967, 77 p, refs. (Contract NAS2-3817) (NASA-CR-73168; TRW-06462-6002-R000) Avail:TAC

Investigations were performed to develop techniques for control of temperature in an extravehicular space suit by passive means. These techniques are intended to be integrated with techniques for passive control of humidity in space suits. The techniques investigated are based on the use of the external suit surface as thermal radiator for rejection of excess metabolic heat and on a space suit shell of controllable overall thermal conductance. The controllable thermal conductance is achieved by a system of thermal insulation which is bypassed by devices similar to "Heat Pipes", modified to provide controllable heat flow rates and geometries applicable to a space suit. Theoretical and experimental investigations demonstrated feasibility of the concept of a variable thermal conductance heat pipe. Concepts for the integration of a variable thermal conductance heat pipe into the fiberglass shell of a hard space suit were developed and fabrication techniques generated.

68017 HEAT PIPE APPLICATION FOR SPACECRAFT THERMAL CONTROL
Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md., D. K. Anand and R. B. Hester, Aug 1967, 94 p, refs., Avail:TAC (Contract NOw-62-0604-c) (TG-922; AD-662241)

A heat pipe is a device which exhibits an extremely high effective thermal conductivity by means of two-phase fluid flow with capillary circulation. The primary objective of the experimental program was to determine a suitable method of control for the heat pipe and to establish suitable wick/fluid configurations for the various temperature ranges of interest. The primary objective of the prototype program was to provide design, construction, testing for verification, and flight hardware specifications of a heat pipe applicable to thermal control of a spacecraft or a spacecraft subsystem. Thus, a thermal design improvement for spacecraft could be proposed; in addition, thermal resistances of heat pipes could be derived.

68018 THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND IN ORBIT
Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md., 29 Apr. 1968, 30 p, refs., Avail:TAC (Contract NOw-62-0604-C) (NASA-CR-94585; S2P-3-25)

The GEOS-2 spacecraft is the first satellite to be equipped with a heat pipe as an integral part of the thermal design. The heat pipe, a device of extremely high effective thermal conductivity, is employed to minimize the temperature differences between transponders located in opposite quadrants of the spacecraft. Measured heat transfer rates through the pipe of as much as 64 watts, together with small temperature gradients on the outside of the heat pipe, are evidence of proper operation. Based on a period of observation of 60 days, transponder maximum and minimum temperatures show improvement over GEOS-1 performance.

68019 HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF SPACECRAFT
Katzoff, S. NASA Langley Research Center, Hampton, Va., (Educational Monograph HT-8-67. NASA Office of Technology Utilization Contract NSR-37-002-045) Avail:TAC (29p), 5 refs.

This monograph reviews the basic theory and application of devices that transfer heat by evaporation of liquid from heated areas and condensation on cold areas, with continuous return of the condensate to the heating area by capillary action. Computed examples are presented to indicate possible applications to the solution of thermal control problems and to illustrate the principles and methods of analysis. Items discussed include wicks and associated capillary structures for optimum transfer of heat and minimum resistance to fluid flow.

69030 ANALYTICAL STUDY PROGRAM TO DEVELOP THE THEORETICAL DESIGN OF SPACE BORNE ELECTROSTATICALLY FOCUSED KLYSTRON AMPLIFIERS
Litton Industries, San Carlos, Calif., Electron Tube Div., W. R. Day and T. H. Luchsinger [1968] 124 p., refs. (Contract NAS3-11515) (NASA-CR-72449) Avail:TAC

The objective was to extend the electrostatically focused klystron (ESFK) art to permit the design of considerably higher efficiency amplifiers for operation in a space environment. Primary emphasis was placed on the critical problems of obtaining higher efficiency and adequate heat transfer while maintaining long operating life, small size and light weight. Voltage jumps, extended interaction output resonators, low perveance electron beams and multistage depressed collectors were found to afford a solution to the problem of efficiency enhancement in ESFK's. A transverse-field depressed collector was conceived which promises to permit high efficiency amplification of AM signals as well as FM signals. The problem of heat transfer associated with spaceborne ESFK's was solved by using a liquid potassium heat pipe radiator operating at 500° C. Electrical and mechanical designs were made for ESFK's intended for TV satellite applications at 0.85, 2.0, 8.0, and 11.0 GHz.

69031 ANALYTICAL STUDY AND EXPERIMENTAL INVESTIGATION OF TECHNIQUES FOR IMPROVING ELECTRON TUBES FOR SPACE APPLICATION
General Electric Co., Philadelphia, Pa., Missile and Space Div., E. C. Conway and M. J. Kelley, Dec. 1968, 229 p., refs. (Contract NAS12-565) (NASA-CR-86118) Avail:TAC

A triode was designed and constructed with a heat pipe integrated into its cathode structure to allow the use of an external heater. A promethium-147 isotope heat source was used to heat the cathode. It was found that a higher power density source, such as curium-244, is much better suited to cathode heating. Using curium-244, the isotope is small enough to be inserted into the cathode support, thus eliminating the need for a heat pipe. An investigation of high power tubes indicated that most existing tubes are not suited to heat pipe cooling, since passages designed for liquid cooling are inadequate for use as evaporators. Integration of heat pipe evaporators into these tubes can be accomplished, however, with either modifications in existing designs or a completely integrated approach to the overall tube design. To demonstrate heat pipe cooling, a travelling wave tube was operated using heat pipe cooling. With 930 watts dissipated at the collector, the operating temperature of 200°C was not exceeded.

69032 HEAT PIPE DEVICES FOR SPACE SUIT TEMPERATURE CONTROL
TRW Systems Group, Redondo Beach, Calif., Arnold P. Shlosinger, Washington, NASA, Research Report, 30 Jun. 1966-1 Sept. 1968, Oct. 1969, 58 p., refs. (Contract NAS2-3817) (NASA-CR-1400; TRW-06462-6005-RO-00) Avail:TAC

Investigations performed to develop techniques for control of temperature in extravehicular space suits have provided technological knowledge of general applicability to temperature control systems. This report summarizes this knowledge. Other reports, referenced in this report, deal with the specific application to space suits and the related materials research performed. A heat pipe thermal switching device is described, and test results presented. Techniques for bonding of capillary structures to solid substrates are discussed. Recommendations for suitable bonding techniques are provided. Heat pipes of flexible materials are described, and data resulting from experimentation with flexible heat pipes presented. Concepts for preventing freezing or for restart of frozen heat pipes are discussed and experiments demonstrating feasibility of one of these concepts are described and data presented.

69033 A HEAT-PIPE-COOLED FAST-REACTOR SPACE POWER SUPPLY
Argonne National Lab., Ill., Reactor Engineering Div., J. J. Roberts, E. J. Croke, R. P. Carter, and J. E. Norco, Jun. 1968, 35 p., refs. (Contract W-31-109-ENG-38) (ANL-7422) Avail:TAC

A fast-spectrum, nuclear-reactor power supply was designed which compares favorably with radioactive isotope sources and SNAP thermal reactors in the 1 to 5 kW(e) range. The use of a ^{239}Pu-based fuel in a relatively simple design, which employs in-core heat pipes and a heat-pipe radiator, yields a comparatively lightweight and low-cost system, which should have good intrinsic reliability. The specific weight for the proposed 1-kW(e) reactor system is about 525 lb/kW(e) (340 lb/kW(e) at 5 kW(e)), as compared to typical weights of about 1000 lb/kW(e) for isotope powered supplies and more than 800 lb/kW(e) for existing SNAP thermal-reactor designs in this power range. Unlike competitive isotopes, ^{239}Pu will be available to meet the anticipated demand for unmanned experimental communication satellites in the 1970's. Moreover, the production cost of this fuel should be approximately 20-70% of the equivalent in isotope power in the 25 to 125 kW(t) power range.

69034 APPLICATION OF HEAT PIPES TO REDUCE CRYOGENIC BOILOFF IN SPACE
J. L. Thurman and E. H. Ingram (Brown Engineering Co., Inc., Huntsville, Ala.).

Journal of Spacecraft and Rockets, vol. 6, Mar. 1969, p. 319-321. 8 refs., Avail:TAC

Description of a concept for reducing cryogenic boil-off during long-term storage in space by means of a heat pipe boil-off control system. The concept is attractive because it is simple, self-contained, maintenance-free, and requires no mechanical pumps or other hardware susceptible to failure. Preliminary calculations indicate that the radiator areas required for a system employing liquid O_2 as the working fluid are not excessive.

69035 APPLICATION OF HEAT PIPE TECHNOLOGY TO ROCKET ENGINE COOLING
S. E. Stephanou, T. E. Ward (McDonnell Douglas Corp., McDonnell Douglas Astronautics Co., Western Div., Santa Monica, Calif.), and J. S. Holmgren (McDonnell Douglas Corp., McDonnell Douglas Astronautics Co., Donald W. Douglas Laboratories, Richland, Wash.). American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 5th, U.S. Air Force Academy, Colorado Springs, Colo., June 9-13, 1969, Paper 69-582. 19p. 6 refs., Avail:TAC

Analytical investigation of the use of heat pipes for the cooling of rocket engines. The rocket motor of the study is assumed to operate at a 100-psia chamber pressure with a 1-in.-diam throat and a thrust of 141 lb; the propellant system utilized is the high-energy space-storable system OF_2/B_2H_6. Two motor designs are considered. In the first, the heat pipe is connected to a space radiator and maintained at about 3500°F. This minimizes the size of the radiator and allows for maximum heat rejection. In the second design, the heat pipe is connected to a heat-rejection device other than a space radiator where the heat flux that can be accommodated is limited--e.g., propellant heat exchanger. Heat fluxes through the heat pipes in the second design are approximately 10% of those for the first design and operating temperatures are much lower (100 to 200°F). For both of the designs, it is shown that the heat-pipe cooling technique is capable of transferring a large portion of heat away from the throat area to other cooling devices, where the heat is rejected. For prolonged operation in space, additional cooling must be utilized; use of these supplementary, more conventional cooling techniques, however, does not diminish the potential utility of heat pipes for rocket engines.

69036 THE "CONSTANT TEMPERATURE" HEAT PIPE - A UNIQUE DEVICE FOR THE THERMAL CONTROL OF SPACECRAFT COMPONENTS
R. C. Turner (Radio Corporation of America, Lancaster, Pa.). American Institute of Aeronautics and Astronautics, Thermophysics Conference, 4th, San Francisco, Calif., June 16-18, 1969, Paper 69-632. 12 p., 12 refs., Avail:TAC

Description of the application of a "constant temperature" heat pipe for the thermal control of spacecraft components. A conceptual design is presented which consists of a "constant temperature" heat pipe coupled to a radiator panel which is comprised of an array of conventional heat pipes. This concept permits the direct thermal coupling of an internal spacecraft component to an external radiator. The radiator location and sizing were optimized for a typical synchronous orbit. The spacecraft was assumed to be cylindrical in shape and spin-stabilized about the central axis at 1 to 3 rps. The component power dissipation was chosen to be 1 to 65 W. The individual heat pipes are joined to the central "constant temperature" heat pipe which carries the heat from the interior of the spacecraft to the external radiator panel. The radiator was sized for an initial power-handling capability of 72 W. A dual inert gas reservoir provides for two distinct operating temperatures of the central heat pipe. One reservoir volume is sized for a 25°C launch temperature, while the second is sized for a 10°C orbital temperature. A unique method for utilizing one or both of these reservoirs is presented. The heat pipe material is 6063T3 aluminum; either acetone or ammonia is used as the working fluid. Helium or argon is used as the inert gas.

69037 AN ATS-E SOLAR CELL SPACE RADIATOR UTILIZING HEAT PIPES
J. D. Hinderman, J. Madsen, and E. D. Waters (McDonnell Douglas Corp., McDonnell Douglas Astronautics Co., Donald W. Douglas Laboratories, Richland, Wash.). American Institute of Aeronautics and Astronautics, Thermophysics Conference, 4th, San Francisco, Calif., June 16-18, 1969, Paper 69-630. 7 p., Avail:TAC

Use of heat pipe technology for thermal equalization around the circumference of 56-in.-diam solar-cell mounting panels on a gravity gradient-stabilized synchronous earth satellite. Thermal tests were conducted to demonstrate heat pipe performance in steady-state and transient (eclipse) conditions. Actual performance of the solar panel/heat pipe substrate showed excellent correlation with predicted performance. Temperature differences between the hot and cold sides of the panels were less than 1/8 of those for panels without heat pipes. The effective solar cell temperature was reduced from 120 to 45°F, resulting in approximately a 20% increase in power output.

69038 ADVANCEMENTS OF SPACE SUIT TEMPERATURE CONTROL TECHNOLOGY BY APPLICATION OF MODIFIED HEAT PIPES
A. P. Shlosinger (TRW Systems Group, Advanced Technology Section, Redondo Beach, Calif.). American Institute of Aeronautics and Astronautics, Thermophysics Conference, 4th, San Francisco, Calif., June 16-18, 1969, Paper 69-619. 9 p., Avail:TAC. Contract No. NAS 2-3817.

Evaluation of the use of heat pipes in radiative transfer from the external surface of a space suit for rejection of body heat. The difficulties in accomplishing this approach and its usefulness are discussed. The concept of a predominantly radiation-cooled space suit, applying modified heat-pipe devices for heat transmission and control of the heat rejection rate, is presented.

69039 SECONDARY POWER
Eugene B. Zwick (Marshall Industries, Inc., Dynamic Sciences Corp., Monrovia, Calif.). Space/Aeronautics, vol. 52, July 1969, p. 143-148, 150. 13 refs., Avail:TAC

Description of secondary power sources for space applications. The increasing requirements of post-Apollo programs for secondary power are outlined. Accordingly, the trend of development at the moment is toward building flightworthy components for high-power, long-duration devices, such as large solar arrays and static and dynamic thermal systems energized by isotopes and reactors, as well as for higher-powered batteries and fuel cells. In keeping with this trend, NASA is currently procuring machinery for a Brayton cycle converter, nonaqueous, sterilizable batteries; and heat pipes for thermal control of low-heat-producing power converters.

69040 PERFORMANCE OF THE GEOS-II HEAT PIPE SYSTEM
R. E. Harkness, APL Technical Digest, vol. 8, May-June 1969, p. 14-49. 6 refs., AVAIL: TAC

The GEOS-2 spacecraft is the first satellite to be equipped with a heat pipe as an integral part of the thermal design. The heat pipe, a device of extremely high effective thermal conductivity, is employed to minimize the temperature differences between transponders located in opposite quadrants of the spacecraft. Measured heat transfer rates through the pipe (as much as 64 W) and the small temperature gradients on the outside of the heat pipe are evidence of proper operation. Based on a 145-day observation period, transponder maximum and minimum temperatures show significant improvement over those of GEOS 1.

69041 DEVELOPMENT OF AN ADVANCED SPACE RADIATION SYSTEM
J. T. Peters and R. G. Hannah (Isotopes, Inc., Baltimore, Md.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03). Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 1010-1015, Avail:TAC

Description of an advanced space radiator system which employs the use of hybrid, water heat pipes to transport waste heat from a radioisotopic thermoelectric generator. The heat rejection system is capable of transporting and rejecting all module design and off-design heat loads. Practical, production-oriented, fabrication techniques have been developed for large length-to-diameter ratio heat pipe assemblies incorporating one or more radii of curvature in a single pipe. Structurally-adequate, curved, radiator panels employing multiple heat pipes have been successfully fabricated utilizing adhesive bonding techniques and have successfully passed thermal performance and thermal cycle testing. The results of the development program on this subsystem have proven that a lightweight, highly reliable space radiator system can be evolved utilizing heat pipes.

69042 AVIONIC APPLICATION OF A HEAT PIPE
A. T. Calimbas and R. H. Hulett (Philco-Ford Corp., Space and Re-Entry Systems Div., Palo Alto, Calif.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03). Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 1016-1024, 8 refs., Avail:TAC. Contract No. AF33(657)-69-C-0420.

Outline of the steps taken to design and develop a heat pipe for an avionic application. Wicking bench tests are used to characterize wick designs from which a final selection is made. The heat pipe is coupled to an air-cooled, compact heat exchanger to dissipate the thermal load into the ambient air. Results of design proof tests verify the adequacy of the cooling subsystem in maintaining the radio component below its maximum allowable temperature for the specified thermal environment.

69043 AN AVIONIC HEAT PIPE
Andy T. Calimbas and Richard H. Hulett (Philco-Ford Corp., Space and Re-Entry Systems Div., Palo Alto, Calif.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-16, 7 p., 8 refs., Avail:TAC. Contract No. AF 33(657)-69-C-0420.

Description of the design, development, and fabrication of a heat pipe to cool a high-power airborne radio component. An air-cooled, compact heat exchanger is coupled with the heat pipe to dissipate the thermal load into the ambient air. Results of design proof tests verify the adequacy of the cooling subsystem in maintaining the radio component below its maximum allowable temperature for the thermal environment defined in MIL-E-5400.

69044 HEAT PIPE RADIATOR FOR SPACE POWER PLANTS
Werner, Richard W.; Carlson, Gustav A. (California Univ., Livermore. Lawrence Radiation Lab.). May 16, 1968 (UCRL-71004). Contract W-7405-eng-48. 17p. (CONF-680802-4). Avail:TAC. From 3rd Annual Intersociety Energy Conversion Engineering Conference, Boulder, Colo.

A heat pipe radiator which forms the ternary loop of a Rankine power system and furnishes meteoroid protection and fluid isolation of the secondary loop is discussed. The radiator design is usable over a broad range of power and its fabrication is well within current technology. A representative value of specific weight which includes feed lines, return lines, manifolds and heater pipes is ~1.1 kg/kW(e) considered for a 20,000 hour mission at 1100°K with a probability of no critical penetrating hits of 0.99.

69045 ANALYSIS OF ADVANCED FAST-SPECTRUM HEAT SOURCES FOR SPACE APPLICATION
McCauley, Edward W.; Brown, Norman J. (Univ. of California, Livermore). Trans. Amer. Nucl. Soc., 11: 432-3 (Nov. 1968). From International Conference on the Constructive Uses of Atomic Energy, Washington, D.C. See CONF-681101, Avail:TAC

69046 HEAT PIPE APPLICATIONS TO GRAVITY-GRADIENT SATELLITE (Explorer XXXVI)
D. K. Anand; ASME--Aviation & Space-Progress & Prospects, Annual Aviation & Space Conference, Beverly Hills, Calif, June 16-19, 1968, p. 634-8; Avail:TAC

Use of two heat pipes, using Freon-11, for thermal control of transponders in gravity-gradient satellite, GEOS-B; orbital results agree with theoretically expected temperature drops over heat pipe regime; a continuous operation over a period of 2 mo indicates no apparent degradation in the performance of the heat pipe; first use of heat pipes for satellite thermal control is complete success.

69047 HEAT PIPES FOR SPACE SUIT TEMPERATURE CONTROL
A. P. Shlosinger, ASME-Aviation & Space-Prospects, Annual Aviation & Space Conference, Beverly Hills, Calif, June 16-19, 1968, p. 634-8; Avail:TAC

Problem of temperature control in space suits; desirability of use of external suit surface as thermal radiator for rejection of metabolic heat is established; the difficulty consists in alternating needs for either high thermal conductance suit shell for preservation of body heat, caused by large temperature difference between solar irradiated and nonirradiated space suit surfaces is explained; approach taken to solution by integration of heat pipe type devices into space suit shell is described.

69048 DESIGN OF 50,000-WATT HEAT-PIPE SPACE RADIATOR
R. C. Turner, W. E. Harbaugh; ASME-Aviation & Space Conference, Beverly Hills, Calif, June 16-19, 1968, p. 639-43; Avail:TAC (9 ref.)

Feasibility of using heat pipes as fundamental units in Rankine space-power-system radiator; analyses show wick-type heat pipes have advantages over "configuration-pumping" type; laboratory tests and computer programs were used to develop wick-type heat pipe that uses only one wrap of wire mesh and weighs only 48 g; weight-to-power ratio of radiator using this heat pipe is 0.24 lb/kw, or only one-third specific weight of earlier systems; meteoroid penetration studies indicate probability of 0.99 of radiator being at least 95% operational at the end of 10,000 hours in near-earth or lunar missions.

70020 A STUDY OF HEAT PIPE APPLICATIONS IN NUCLEAR AIRCRAFT PROPULSION SYSTEMS
Calvin C. Silverstein, Baltimore, Md., Final Report, 1 Dec., 1969, 110 p., refs.

(Contract NAS3-11841) (NASA-CR-72610; SIL-104), Avail:TAC

Preliminary studies of heat pipe systems for reactor-to-jet engine heat transport and for emergency distribution of reactor afterheat over the surface of the reactor containment vessel are described. The reactor-to-jet engine heat transport system includes 5480 small-diameter reactor heat pipes, four large-diameter adiabatic heat transport pipes, and 8300 small-diameter heat pipes in each of the four engine heat exchangers. The total system weight is about 47,000 lb. The emergency afterheat distribution system includes 4280 heat pipes 1 in. in diameter and 11.7 in. long, whose total weight is 3400 lb.

70021 HEATPIPES AND VAPOUR CHAMBERS FOR SATELLITE THERMAL BALANCE
Royal Aircraft Establishment, Farnborough (England)., C. J. Savage, June, 1969, 39 p., refs. (RAE-TR-69125) Copyright. Avail:TAC

Heat pipes and vapor chambers, employing the principles of vapor heat transport, may be constructed with thermal conductances far higher than a solid metal structure with similar dimensions. The operation of these devices is described, and quantitative estimates are obtained of the performance to be expected from them. Ways in which they may be used to assist satellite thermal control are discussed.

70022 NEUTRONIC DESIGN OF A REACTOR CORE CONTAINING HEAT PIPES FOR APPLICATION TO A NUCLEAR AIRPLANE
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Richard L. Puthoff [1969], 21 p., refs. (NASA-TM-X-52765; E-5571) Avail:TAC

A study was conducted to perform the neutronic calculation on the proposed heat pipe reactor design. The study revealed that utilizing heat pipes for a nuclear airplane reactor application appeared promising when heat pipe performance was applied to the limit of heat pipe technology. The design parameters calculated are number of heat pipes, radial heat flux, core diameter, cord L/D, heat pipe vapor temperature, fuel enrichment, fuel loading, clad temperature, clad stress, and power.

70023 SPACE EXPERIMENT THERMAL DESIGN
National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md., M. Schach. In Univ. Coll., London, Prelim. Design of a Cosmic X-ray Survey Expt., Oct. 1969, p. 61-71 (See N70-24826 11-30) Avail:TAC

The estimation of maximum and minimum temperatures and temperature gradients in spacecraft components, subsystems etc. are discussed together with the use of thermal control coatings, multilayer insulation and thermomechanical devices such as louvers and heat pipes. The thermal analysis of experiments in terms of thermal modes and instantaneous power balances is considered in detail. Thermal simulation procedures are also outlined.

70024 APPLICATION OF HEAT PIPES TO A NUCLEAR AIRCRAFT PROPULSION SYSTEM
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Richard L. Puthoff and Calvin C. Silverstein [1970], 20 p., refs. Proposed for presentation at the 6th Propulsion Joint Specialists Conf., San Diego, Calif., 15-19 Jun. 1970; sponsored by AIAA (NASA-TM-X-52791) Avail:TAC

A preliminary study was conducted to determine the feasibility of using heat pipes in a nuclear aircraft propulsion system. Heat pipes were the sole transporter of heat. Three sodium coolant heat pipe systems were used. One transferred the heat from the reactor. Another transferred the heat to the air in the jet engine. The third heat pipe transferred the heat from the reactor pipe to the jet engine heat pipe. To get promising performance, the technology had to be pushed to the limit.

70025 HEAT PIPE TECHNOLOGY FOR ADVANCED ROCKET THRUST CHAMBERS
Aerojet Liquid Rocket Co., Sacramento, Calif., Dept. of Engine Components, D. C. Rousar, Interim Report, 3 Jan. 1969-2 May 1970, 24 Jul. 1970, 178 p., refs. (Contract NAS7-697) (NASA-CR-110735; Rept. 697-i) Avail:TAC

An initial design study of heat-pipe-cooled thrust chambers is summarized. The program was aimed at applying heat pipe technology to the cooling of high energy space storable propellants and a specific goal was the design and fabrication of a working model OF_2/B_2H_6 thrust chamber cooled by the heat pipe principle. Program tasks reported include: (1) heat pipe technology review; (2) analysis and experimentation; and (3) working model design.

70026 APPLICATION OF HEAT PIPES TO SPACECRAFT THERMAL CONTROL PROBLEMS
Brown Engineering Co., Inc., Huntsville, Ala., Research Labs., J. L. Thurman and S. Mei, Jul. 1968, 102 p., refs. (Contract NAS8-20073) (NASA-CR-109991; TN-AST-275) Avail:TAC

The applicability of heat pipes to the solution of thermal control problems associated with future spacecraft, including the Saturn V workshop is investigated. The investigation includes a survey of reported experience in heat pipe technology, an analysis of the effect of variation in various design parameters on heat pipe performance, and establishment of concepts utilizing the heat pipe which offer unique solutions to specific thermal control problems. Concepts are described and analyzed which appear applicable to the solution of problems of cryogenic boiloff control, temperature nonuniformity of skin structure, removal of heat from concentrated sources, and radiator design.

70027 A MILLIMETER WAVE PARABOLIC ANTENNA FOR COMMUNICATIONS WITH A SYNCHRONOUS SATELLITE
R. J. Eby and G. I. Goldberg (Fairchild Hiller Corp., Space and Electronics Systems Div., Germantown, Md.). IN: AEROSPACE STRUCTURES DESIGN CONFERENCE, SEATTLE, WASH., AUGUST 4, 5, 1969, PROCEEDINGS. (A70-11931 02-32). Conference sponsored by the Seattle Professional Engineering Employees Association, the American Institute of Aeronautics and Astronautics, the Boeing Co., the University of Washington, and the Pacific Science Center. Seattle, Wash., Seattle Professional Engineering Employees Association, 1969, p. 2-1 to 2-13, Avail:TAC NASA-supported research.

Discussion of a systems engineering study of a millimeter wave parabolic dish antenna mounted on a satellite which continuously tracks a communication satellite in a synchronous orbit. Electrical and thermostructural considerations show that a major problem area in effecting an acceptable design is the elimination of thermal gradients which would result in distortions restricting antenna gain and frequency. A description and evaluation of a heat pipe network system which creates near isothermal conditions on the antenna surface are presented.

70028 THERMAL CONTROL (TERMOREGULIROVANIE)
A. Serov and V. Shishina, Aviatsiia i Kosmonavtika, Jan. 1970, p. 26, 27. In Russian. Avail:TAC

Discussion of factors affecting the heat balance of a spacecraft in space and in planetary atmospheres, and evaluation of passive and active methods of thermal control. Conditions affecting planetary probes for earth, Mars, and Venus are analyzed, together with the heat inputs due to solar radiation and planetary albedos. Attention is given to the use of reflective coatings, insulations, and heat pipes. Open- and closed-cycle active cooling systems are discussed, along with control of the spacecraft's optical characteristics.

70029 CONCEPTUAL DESIGN OF A 10-MWe NUCLEAR RANKINE SYSTEM FOR SPACE POWER
John H. Pitts and Carl E. Walter (California, University, Livermore, Calif.). Journal of Spacecraft and Rockets, vol. 7, Mar. 1970, p. 259-265. 12 refs. AEC-sponsored research, Avail:TAC

The conceptual design of a 10-MWe Rankine system for nuclear-electric space power is described. A compact nuclear reactor operating at 1650 deg K uses uranium mononitride as the fuel, lithium as the coolant, and tungsten-25% rhenium as a structural material. The reactor is controlled by a dual control system consisting of lithium-6 liquid control tubes and a movable molybednum side reflector. A lithium-hydride and tungsten nuclear shield, which reduces radiation to an acceptable dose for a manned payload over a 10,000-hr life, is provided. The shield accounts for about half the total system specific mass of 7 kg/kWe. A lightweight heat-pipe radiator rejects waste heat at 1100 deg K. Overall system efficiency is 17.5%.

70030 UNIDIRECTIONAL HEAT PIPES TO CONTROL TWT TEMPERATURE IN SYNCHRONOUS ORBIT
A. Basiulis (Hughes Aircraft Co., Electron Dynamics Div., Torrance, Calif.). In: Thermodynamics and thermophysics of space flight; Proceedings of the Symposium, Palo Alto, Calif., March 23-25, 1970. (A70-26351 11-32). Symposium sponsored by the U.S. Air Force and the Lockheed Missiles and Space Co., Sunnyvale, Calif., Lockheed Missiles and Space Co., 1970, p. 165-173, 5 refs. Contract No. NAS 3-9719, Avail:TAC

This paper discusses the principles of the unidirectional heat pipe (unipipe), its application to spacecraft thermal control, and the design of a multiple heat pipe system to control the temperature of high power traveling-wave tubes. Thermal analysis during one orbit of a synchronous communications satellite dissipating 5 kW of waste heat is presented along the experimental results for unidirectional heat pipe.

70031 HEAT-PIPE-COOLED THRUST CHAMBERS FOR SPACE STORABLE PROPELLANTS
D. C. Rousar (Aerojet Liquid Rocket Co., Sacramento, Calif.). American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 6th, San Diego, Calif., June 15-19, 1970, Paper 70-942. 7 p., 10 refs. Contract No. NAS 7-697, Avail: TAC

Discussion of the design considerations, experimental results, and evaluation for heat-pipe cooled thrust chambers for space storable propellants. A design concept consisting of an annular shaped sodium/nickel heat pipe with a regeneratively cooled condenser was chosen for a thrust chamber which will be designed to operate with OF2 and B2H6 propellants at 100 psia chamber pressure. The feasibility of fabricating a heat pipe in the shape of a rocket thrust chamber has been demonstrated and heat fluxes up to 5 Btu/sq in sec have been achieved in laboratory test devices. Lithium and silver are also shown to be potential working fluids for heat pipe thrust chambers; however, their near-term application for OF2/B2H6 thrust chambers is hindered by chemical compatibility problems.

71010 HEAT PIPES IN SATELLITE TECHNOLOGY (WÄRMEROHRE IN DER SATELLITENTECHNIK)
P. Zimmerman and M. Groll (Stuttgart, Universität, Stuttgart, West Germany). Raumfahrtforschung, vol. 14, Sept.-Oct. 1970, p. 189-192. 16 refs. In German, Avail:TAC

Heat pipes are construction elements with very high thermal conductance at small temperature gradients. A description of physical principles of heat pipes and of possible combinations of structure material and heat carrier for several temperature ranges is given. Some typical examples for space applications of heat pipes are discussed.

71011 BRAYTON CYCLE VAPOR CHAMBER (HEAT PIPE) RADIATOR STUDY
Gerrels, E. E., and J. W. Larson (General Electric Co.), Contract NAS 3-10615, GESP-7030, Feb. 1971. Avail:TAC, 279p.

The vapor chamber (heat pipe) radiator is defined and evaluated as a potential candidate for rejecting waste heat from a Radioisotope Brayton Cycle space power system. A comparison is made with an operationally equivalent conduction fin radiator. Both radiators employed DC-200 heat transfer fluid within the primary ducts and aluminum as the basic structural material. Vapor chamber fluids are evaluated and selected for thermal performance and containment within the radiator. Vapor chamber compatibility and performance tests are made for a number of candidate fluids. Preliminary designs are developed for both conduction fin and vapor chamber radiator concepts. A comparison shows no significant advantges attributable to the Brayton cycle vapor chamber radiator where reliability and meteoroid criteria specify 0.99 to 0.999 probability of survival over a five-year lifetime.

71012 HEAT PIPE SYSTEM FOR SPACECRAFT THERMAL CONTROL
T. R. Scollon, Jr., General Electric Co., Valley Forge, Pa., AIAA 6th Thermophysics Conf., April 26-28, 1971, Avail:TAC

Circumferential heat pipes were fabricated to conform to the periphery of a large spacecraft to transfer component and solar heat to available rejection areas. A full-scale model of the vehicle was assembled including louvers, insulation, electrical heaters, realistic structural detail, and the heat pipe system. The model was tested in a simulated space environment. Operational heating modes were imposed and performance was observed with heat pipes both charged and empty. Results indicated that the heat pipes did reduce temperature gradients but the requirements of the selected vehicle could be met without the plexity of the heat pipe system.

71013 HEAT PIPE APPLICATIONS TO SPACE VEHICLES
John Roukis, Jerry Rogovin, and Burt Swerdling, Grumman Aerospace Corp., Bethpage, N.Y., AIAA 6th Thermophysics Conf., April 26-28, 1971, Avail:TAC

Several attractive areas of heat pipe applications to space vehicle thermal control are presented and reviewed through a discussion of NASA requirements for future manned and unmanned spacecraft. Particularly noted are the areas of space radiators, experiment/equipment temperature control, structure isothermalization, and heat exchangers. In each case specific thermal control requirements and solutions are discussed relative to the potential application of heat pipe technology. Results are presented which indicate significant performance improvement possibilities and emphasize the necessity for including heat pipes in the thermal design of space vehicles.

71040 FEASIBILITY STUDIES OF SPACE RADIATORS USING VAPOR CHAMBER FINS
H. C. Haller and S. Lieblein, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. In: Proceedings of Joint Atomic Energy Commission/ Sandia Laboratories Heat Pipe Conference, Vol. I, October 1966, p. 47-67, SC-M-66-623, Avail:TAC

The purpose of this paper is to define and present the wicking material properties that are considered to be important to the operation of a heat pipe. Three classes of wicking materials are studied: sintered metal screens, sintered metal powders, and sintered metal fibers. The porosity of these sintered materials ranges from 47.7 to 91.8 percent. Two characteristics of the wicking material are considered to limit the operation of the heat pipe. These are: (1) the capillary pumping characteristics of a wick; and (2) the evaporative heat transfer characteristics of a liquid-saturated wick. To evaluate the effect of capillary pumping characteristics, a simplified analysis of a planar wick pipe is made. The result of this analysis gives the maximum operating length of a planar wick model in terms of the external boundary conditions, the heat pipe fluid properties, and the capillary pump characteristics of the wicking material. The capillary pump characteristics are found to be proportional to the equilbrium height to which the heat pipe liquid will rise in the wicking material divided by the wicking material friction factor. The latter is the reciprocal of the permeability for the wicking material. The results of wick equilibrium height experiments and wick permeability experiments run on the three classes of wicking materials are presented. Both water and Freon 113 are used in these experiments. These results are combined to yield the capillary pumping characteristics of each wicking material tested. To evaluate the effect of the evaporative heat transfer characteristics of wicks, experimental data on porous samples selected from the three classes of wicking materials is presented. These data result from evaporative heat transfer experiments run on planar wick samples saturated with water. All experimental results are compared with the heat transfer characteristics of a flat plate submerged in water. The data indicate that the entrapment of vapor bubbles in the wick matrix may cause the premature occurrence of film boiling in the porous material at relatively low heat fluxes, depending on the structure of the wicking material.

71042 CONCEPTUAL DESIGN OF A RADIOISOTOPE HEAT-PIPE-THERMIONIC SPACE POWER SYSTEM
Altieri, D., Parker, J., Jr., Intersociety Energy Conversion Engrg. Conf., Boulder, Colo., Aug. 13-17, 1968.

B.4 NUCLEAR SYSTEMS

67033 DESIGN OF A 1 KWE FAST REACTOR POWER SUPPLY
John J. Roberts and Edward J. Croke (Argonne National Laboratory, Argonne, Ill.). IN: ADVANCES IN ENERGY CONVERSION ENGINEERING: AMERICAN SOCIETY OF MECHANICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, MIAMI BEACH, FLA., AUGUST 13-17, PAPERS. [A67-42485 24-03]. New York, American Society of Mechanical Engineers, 1967, p. 575-586. 25 refs., Avail:TAC AEC-sponsored research.

Description of a fast-spectrum, nuclear-reactor power supply which compares favorably with radioactive isotope sources and SNAP thermal reactors in the 1 to 5-kwe range. The use of a Pu 239-based fuel in a comparatively simple design which employs in-core heat pipes and a heat pipe radiator yields a lightweight and low-cost system. A survey of potential fuels is presented, and areas such as control, heat-transfer analysis, and reactor optimization are also considered.

68020 COOLING SYSTEM FOR NUCLEAR REACTORS
Bohdansky, J.; Busse, C.; Grover, G. M. (to EURATOM). Canadian Patent 765,919. Aug. 22, 1967. Priority date Dec. 14, 1964, Germany.

In this reactor, especially designed for direct conversion of heat to electricity, a "heat pipe" is used instead of continuous fluid flow for heat transfer. The tubular fuel element surrounds a heat pipe which contains a quantity of liquid metal and is lined with a wick. Similar pipes are inserted into the moderator and reflector. The reactor core is horizontal and these pipes terminate in heat sinks to the right and left ends of the core. Heat transfer occurs by a cycle of vaporization and condensation of liquid returning by capillary action along the wick lining. The heat is converted to electricity by thermionic emitters and collector electrodes located in the heat sinks. Ag, Li and Cs are used as heat carrier fluids for the vaporization-condensation cycle depending on the temperature range required. Operating temperatures are 1800°C at the emitter electrode, 1000°C at the collector electrode and 500°C in the moderator and reflector.

68021 ISOTHERMAL IRRADIATION ASSEMBLY FOR STUDY OF FAST NEUTRON DAMAGE TO CERAMICS
Ranken, W. A.; Summers, C. S. (Los Alamos Scientific Lab., N. Mex.). [1966]. Contract W-7405-eng-36. 5 p. (LA-DC-9025). (CONF-671045-5). Avail:TAC, from IEEE Thermionic Conversion Specialist Conference, Palo Alto, Calif.

Knowledge of the effect of fast neutron irradiation on the electrical, thermal and mechanical behavior of the ceramic and the bonded ceramic-metal components required for thermionic fuel rod construction is as yet very limited in extent. The EBR-II is a desirable facility for obtaining such data since its neutron spectrum is similar to that occurring in most thermionic reactor designs and the extrinsic testing cost is low. However, this facility has the disadvantage that temperature control and measurement must be accomplished without physical connections to the exterior of the reactor vessel. Therefore it has been necessary to develop irradiation assemblies in which the sample temperature can be preset and maintained to within 15°C despite inaccurate knowledge of gamma ray heat generation rates in the testing region. These isothermal irradiation unit designs feature gas-filled stainless steel heat pipes with sodium working fluid. Operating temperature is established by the amount of gas initially introduced into the heat pipes. Results of testing the assemblies both in the laboratory and in the Omega West Reactor are given.

68022 ADVANCED SPACE NUCLEAR POWER PROGRAM
Quarterly Report, July-September 1967. (California Univ., Livermore. Lawrence Radiation Lab.). Contract W-7405-eng-48. 123 p. (UCRL-50004-67-3(Pt. 1)). Avail:TAC

RHENIUM ALLOYS AND SYSTEMS--Re-W, creep behavior of, effects of composition and heat treatments on; Hf-Mo-Re-W, surface hardness of, effects of hafnium content on

NUCLEAR AUXILIARY POWER SYSTEMS--kinetics for SPR-4 reactor, use of ZOOM computer codes for calculation of; kinetics for SPR-6 reactor, use of ZOOM computer code for calculation of; physics measurements for SPR-5 reactor, description of optimum; physics measurements for SPR-8 reactor, description of optimum; shielding calculations for, description of GEISHA-2 computer code for; configuration of SPR-6 reactor, reference design

THORIUM OXIDES ThO_2--ThO_2-W, density and weight loss of sintered, effects of heating rate on

TUNGSTEN--creep behavior of, effects of composition and heat treatments on

HAFNIUM NITRIDES--HfN-W, co-vapor deposition of, effects of nitrogen on

URANIUM NITRIDES UN--metallurgical properties of, effects of temperature and pressure on

THERMODYNAMICS--saturation enthalpy and entropy for liquid or gas, calculation of, (E/T)

HEAT TRANSFER SYSTEMS--configuration of SPR-6 reactor, reference design

REACTOR FUEL ELEMENTS--assemblies of SPR-6 reactor, reference design

REACTOR CONTROL SYSTEMS--reactivity response for SPR-6 reactor, description of
HEAT PIPES--configuration of SPR-6 reactor, reference design

68023 EXPERIMENTS FOR SIMULATING HEAT TRANSFER FROM A REACTOR SURFACE TO CESIUM VAPOR CONVERTERS
Koeppe, A. (Stuttgart Univ. (West Germany)). Feb. 15, 1968. 17 p. (In German). (BMwF-FBK-68-18)

Experiments for simulating heat transfer by radiation from a reactor surface to a thermionic converter with a heat pipe-radiator are described. A cesium diode for a SRAST-W system was built and a description in terms of design and data is given. The results of measurement on a front wall heated heat pipe are discussed. Technological problems of a cesium diode by electron beam welding are considered.

69049 CONCEPT FOR A GAS BUFFERED ANNULAR HEATPIPE FUEL IRRADIATION CAPSULE
California Univ., Livermore. Lawrence Radiation Lab., J. D. Lee and R. D. Werner, 25 Jul. 1968, 25 p., refs. (Contract W-7405-ENG-48) (UCRL-50510) Avail:TAC

A nuclear fuel irradiation capsule capable of handling large ($\approx$300 W/cm^2) and varying fuel specimen heat fluxes while inherently maintaining nearly constant specimen temperature was conceived and two bench models successfully tested using potassium and sodium as the working fluids. Test temperatures were in the 700°C range and heat source temperatures were preserved within $\pm$15°C while undergoing factors of three changes in power.

69050 REACTIVITY SELF-CONTROL ON POWER AND TEMPERATURE IN REACTORS COOLED BY HEATPIPES
Hampel, Viktor E.; Koopman, Ronald P. (California Univ., Livermore. Lawrence Radiation Lab.). Nov. 1, 1968. Contract W-7405-eng-48. 83p. (UCRL-71198) (CONF-681101-9). Avail:TAC. From International Conference on the Constructive Uses of Atomic Energy, Washington, D.C.

Fluid dynamics in heatpipes are shown to transfer between 5 and 10% of the fluid mass from the evaporator end to the condenser end during normal operation as a function of radial heat flux. These effects were studied for K, Na, Li, BeF_2, Ag, and LiF in computer optimized heatpipes for mesh dimensions between 0.0075 and 0.0325 cm and for temperatures between 1300 and 2400°K. It is shown that this transfer of mass can be utilized in reactors cooled by heatpipes to yield strong negative reactivity effects when fluids with negative void coefficients are employed. (40 references)

69051 COMPACT POWER CONCEPT FEATURES A FAST REACTOR, HEAT PIPES, AND DIRECT CONVERTERS
Roberts, John J.; Croke, Edward J. Reactor Fuel-Process. Technol., 11: 187-200 (Fall 1968).

BERYLLIUM OXIDES--physical properties of

CRITICALITY STUDIES--measurements for optimum beryllium oxide (BeO)-reflected plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor core configuration

HEAT PIPES--design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled thermoelectric fast reactor

NUCLEAR AUXILIARY POWER SYSTEMS--design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor

PLUTONIUM PHOSPHIDES--physical properties and nuclear properties of

RADIATORS--design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor

REACTIVITY--measurement of beryllium oxide (BeO)-reflected plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor, effects of configuration on optimum

REACTOR FUEL ELEMENTS--design parameters for conceptual 1 to 5 kW(e) fast thermoelectric reactor hexagonal-shaped heat-pipe-containing plutonium phosphide (PuP)

REACTORS, FAST--design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric

REACTORS, POWER--design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast

THERMOELECTRIC CELLS--design parameters for conceptual plutonium phosphide (PuP)-fueled heat-pipe fast reactor 1 to 5 kW(e)

69052 THERMAL CONTROL AND POWER FLATTENING FOR RADIOISOTOPIC THERMODYNAMIC POWER SYSTEM
Bienert, Walter Bruno; Levedahl, William John; Streb, Alan Joseph (to Martin-Marietta Corp.). British Patent 1,160,568. Aug. 6, 1969. Filed Nov. 21, 1966.

An improved radioisotope powered thermodynamic system is described which incorporates a heat pipe for rejection of excess heat. The rejection of excess heat may be readily varied over the life of the radioisotopic fuel using a method which involves no mechanically moving parts. The amount of heat transferred between the ends of the heat pipe is determined by the rate of movement of the working fluid, which moves as a gas through the void and as a liquid, by capillary action through the pipe lining.

69053 CONCEPT FOR A GAS BUFFERED ANNULAR HEATPIPE FUEL IRRADIATION CAPSULE
Lee, J. D.; Werner, R. W. (California Univ., Livermore. Lawrence Radiation Lab.). July 31, 1969. 32 p. (UCRL-71889) (CONF-690910-1). Avail:TAC. From Symposium on Developments in Irradiation Testing Technology, Sandusky, Ohio.

A nuclear fuel irradiation capsule capable of handling large ($\approx$300 W/cm^2) and varying fuel specimen heat fluxes while inherently maintaining nearly constant specimen temperature was conceived and two bench models successfully tested using potassium and sodium as the working fluids. Test temperatures were in the 700°C range and heat source temperatures were preserved within $\pm$15°C while undergoing changes in power by factors of three.

70033 THE MODULE APPROACH TO BLANKET DESIGN: A VACUUM WALL FREE BLANKET USING HEAT PIPES
California Univ., Livermore. Lawrence Radiation Lab., R. W. Werner, 13 Aug. 1969, 38 p., refs. Presented at the Intern. Conf. on Nucl. Fusion Reactors, Culham, England. Sponsored by AFC. (UCRL-71758; Conf-690901-2), Avail:TAC

An analysis has been made of the blanket surrounding the thermonuclear plasma which is required to moderate neutrons, provide for kinetic to thermal energy conversion, remove the thermal energy produced, and regenerate the tritium burned in the D-T reaction. The study introduces two new features to blanket design: heat pipes and a modular structure. The study relocates the "standard" vacuum wall of a thermonuclear reactor outboard of the neutron-moderating, energy-converting blanket and thus places the entire moderator in a vacuum envelope and in an unobstructed view of the plasma. The new blanket is structurally designed in modular units which radially and tangentially interlock to form a neutron closed cylinder. The modules consist of sets of thin walled tube banks which have common mass flow and common pressure requirements so that structural design is simple and replacement straightforward. A reference design operating at approximately 1100 K and using natural lithium as a moderator and sodium heat pipes is discussed.

70034 ACHIEVING UNIFORM SPECIMEN TEMPERATURES IN AN IRRADIATION CAPSULE USING HEAT PIPES
Zielenbach, W. J.; Miller, N. E. (Battelle Memorial Inst., Columbus, Ohio) (CONF-690910-, pp. 157-64), Avail:TAC

Results of laboratory studies indicate that a lithium-filled annular heat pipe is feasible as a means of obtaining near isothermal conditions axially along the surface on the cladding of a short fuel sample in an in-pile fuel-irradiation capsule. At a 1500°C operating temperature the axial spread of temperatures was less than 20°C along a three inch length in an experiment simulating the irradiation capsule. The annular heat pipe would be incorporated into the current capsule configuration employed in the high-temperature-fuels program to achieve uniform specimen cladding temperatures of 1600 to 1900°C.

70035 ISOTOPE KILOWATT PROGRAM
Quarterly Progress Report for Period Ending June 30, 1970. (Oak Ridge National Lab., Tenn.). Sept 1970. Contract W-7405-eng-26. 28 p. (ORNL-TM-3099), Avail:TAC

A heat block-shield design has been evolved that is suitable for all three power conversion systems under study. This unit has the further advantage that it can be used with either $SrTiO_3$ or SrF_2 fuel. A preliminary design for a reduced scale test loop to evaluate the thermal radiation stability characteristics of Dowtherm A has been prepared and is being reviewed critically. A conceptual design of a heat pipe test has been prepared, and preliminary arrangements for fabrication of a test unit have been initiated. The design and construction of a full-scale thermoelectric module has been discussed with 3-M and it has been concluded that the principal problems associated with integrating the junctions into a complete heat pipe module assembly are much the same for lead telluride and the more efficient advanced material under development. As a consequence, it appears that the next step after a test of a heat pipe tailored to this special application should be a test of a full scale thermoelectric module with lead telluride junctions. A firm proposal from 3-M to fabricate such a unit is expected early in the next quarter.

70036 INDEPENDENT HEAT PIPES
Cherkasskii, A. Kh., Akad Nauk. Iz., Energetika i Transport n 3 May-June 1969 p 95-103

Possibility is examined for designing new type of local heat pipe for intensive heat transfer from heat source to heat receiver over long distances; the study is of interest to nuclear reactor engineering.

71014 A SPLIT-CORE HEAT-PIPE REACTOR FOR SPACE POWER APPLICATIONS
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, George Niederauer and Edward Lantz [1970] 10 p., refs. Presented at the 1970 Thermionic Conversion Specialist Conf., Miami Beach, Fla., 26-29 Oct. 1970; sponsored by IEEE (NASA-TM-X-52918) Avail:TAC

The design and operation of small U-235C- and U-233C-fueled cores with axial heat pipes for a 350 kWe out-of-core thermionic power system was investigated. A split in the core at midplane was used for reactivity control. Each half core was built up from modules, each of which consisted of a fuel element with a central heat pipe that extended beyond the axial reflector. With 1 cm-diameter heat pipes a typical U235 core has a 30 cm diameter and contains 123 kg of U235 and a typical U233 core has a 24 cm diameter and contains 55 kg of U233. The physics of the design concept are presented for both U-235C and U-233C systems. A study of the startup dynamics of the reactor and heat pipes shows that ramp reactivity inputs should be limited to less than 2 cents/sec for the U-233 reactor and less than 8 cents/sec for the U-235 reactor.

71015 CONCEPTUAL DESIGN OF A 2-Mwt (375 kwe) NUCLEAR-ELECTRIC SPACE POWER SYSTEM
John H. Pitts and Carl E. Walter (California, University, Livermore, Calif.). Journal of Spacecraft and Rockets, vol. 7, Nov. 1970, p. 1282-1286. 15 refs. AEC-sponsored research, Avail:TAC

Description of a power system which includes a unique nuclear reactor-boiler unit operating at 1500 K that utilizes heat pipes in lieu of a conventionally pumped primary loop. An efficient heat-pipe radiation rejects waste heat at 1035 K. Overall system efficiency is 18.8%, yielding a net electrical output of 375 kwe. The system specific mass is 10 kg/kwe, including a generous shadow shield for unmanned payloads.

B.5 ELECTRONIC APPLICATIONS

68024 HIGH-POWER GRIDDED TUBES - 1968
T. E. Yingst, RCA Electronic Corp., Lancaster, Pa., Avail:TAC (2p) 13 refs.

The latest development of high-power grid-controlled tubes is outlined. The advantage of using the heat pipe principle with the cooler are described briefly.

69054 AN ELECTRICALLY INSULATED HEAT PIPE FOR DEPRESSED COLLECTORS
A. Basiulis and J. C. Dixon (Hughes Aircraft Co., Electron Dynamics Div., Torrance, Calif.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, CONFERENCE ON TUBE TECHNIQUES, 9TH, NEW YORK, N.Y., SEPTEMBER 17, 18, 1968, CONFERENCE RECORD. [A69-24740 11-09]. New York, Institute of Electrical and Electronics Engineers, Inc., 1968, p. 176-181. 14 refs., Avail:TAC

Description of the design of a heat transfer device and electrical insulator for service as an integral part of a traveling-wave tube collector. Heat-pipe cooled collectors have operated at a power density of 47.8 W/in.^{2} for 1500 hr without degradation in performance. Collector depression was maintained at 12,000 V during operation and during shut down. Voltage breakdown problems common to insulators operated in air do not occur because of elimination of possible contamination along with the air itself.

69055 COOLING OF A HIGH-POWER ELECTRON TUBE IN A SPACE VEHICLE
E. C. Conway (General Electric Co., Missile and Space Div., King of Prussia, Pa.) and R. W. Wilmarth (NASA, Electronics Research Center, Cambridge, Mass.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS CONFERENCE ON TUBE TECHNIQUES, 9TH, NEW YORK, N.Y., SEPTEMBER 17, 18, 1968, CONFERENCE RECORD. [A69-24740 11-09]. New York, Institute of Electrical and Electronics Engineers, Inc., 1968, p. 182-190. 12 refs., Avail: TAC. Contract No. NAS 12-565.

Description of a thermal control system built to provide cooling for a traveling wave tube (TWT) mounted in a spacecraft. The system was designed to demonstrate the capability of heat pipes to provide high thermal conductance paths for 750 W (dissipated at the TWT collector) to flow to a flat plate radiator where the heat can be radiated to space. The evaporators of four heat pipes and the TWT collector are attached to a block located at the center of the radiator. The heat pipe condensers, placed along the diagonals of the square radiator plate, maintain the diagonals very nearly isothermal, thus keeping the fin effectiveness high. Test results are included, showing the system thermal performance in several modes of operation for varying power dissipations. The results of failure of one, two, three, or all four pipes are presented. Also included is an analytical investigation of the weight and area requirements of both passive and heat-pipe space radiators. This analysis serves as a general guide in judging the effect of temperature limits and power dissipation on the thermal control system.

69056 NONELECTRIC CATHODE HEATING
E. C. Conway, M. J. Kelley (General Electric Co., King of Prussia, Pa.), R. W. Wilmarth (NASA, Electronics Research Center, Cambridge, Mass.), and J. E. Beggs (General Electric Co., Research and Development Center, Schenectady, N.Y.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, CONFERENCE ON TUBE TECHNIQUES, 9TH, NEW YORK, N.Y., SEPTEMBER 17, 18, 1968, CONFERENCE RECORD. [A69-24740 11-09]. New York, Institute of Electrical and Electronics Engineers, Inc., 1968, p. 191-195, Avail:TAC. Contract No. NAS 12-565.

Description of a vacuum tube which has been constructed to obtain more efficient utilization of heat than is provided by thermoelectric or thermionic devices. The vacuum tube is such that its cathode is directly heated by a radioisotope source external to the tube. The tube design incorporates a heat pipe to provide almost isothermal transfer of heat from the external source to the cathode. Test results demonstrate operation with an external electrical heater and a radioisotope heat source.

69057 HEAT PIPES AND THEIR APPLICATION TO THERMAL CONTROL IN ELECTRONIC EQUIPMENT
Thomas D. Sheppard, Jr. (Bendix Corp., Navigation and Control Div., Teterboro, N.J.). IN: NATIONAL ELECTRONIC PACKAGING AND PRODUCTION CONFERENCE, ANAHEIM, CALIF., FEBRUARY 11-13, 1969, AND PHILADELPHIA, PA., JUNE 10-12, 1969, PROCEEDINGS OF THE TECHNICAL PROGRAM. (A69-39941 22-09). Chicago, Industrial and Scientific Conference Management, Inc., 1969, p. 25-52. 19 refs., Avail:TAC

Discussion of the relation of the properties of heat pipes to their performance in applications to thermal control in electronic equipment. The applications considered are those that have been specifically evaluated for potential use, or tested to establish feasibility, and applications which are simply presented conceptually. Constant temperature heat pipes used as a space radiator are considered, and a design concept using constant-temperature heat pipes is shown, together with a heat pipe used to remove heat from the hot side of a thermoelectric heat pump. A configuration which will make it possible to make a workable heat pipe for a nominal expense is shown.

69058 HEAT PIPE DESIGN FOR ELECTRON TUBE COOLING
A. Basiulis and J. C. Dixon (Hughes Aircraft Co., Electron Dynamics Div., Torrance, Calif.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-25. 11 p., 11 refs., Avail:TAC

Discussion of the design of heat pipes for cooling electron tubes operating at temperatures ranging from minus 40 to 300 deg C. Special attention is given to the heat pipe cooling of traveling-wave tubes. A review is presented of different heat pipe configurations, emphasis being given to a heat pipe, which is especially suitable for TWT collector cooling. The design and characteristics of a dielectric heat pipe are examined. The use of a dielectric heat pipe for cooling a traveling-wave tube is described.

69059 APPLICATIONS OF HEAT PIPES IN ELECTRONIC EQUIPMENT
Dutcher, C. H., Burke, M. R., Keenan, R. K., Electronic Communications, Inc., Rpt. No. AER-69-0011, Avail:TAC (36p) 6 refs.

This paper represents a heuristic presentation of heat pipe principles with particular emphasis on applications to electronic equipment. A fairly detailed account of the external characteristics of heat pipes is given, with particular attention to electronic equipment.

70037 LARGE TELESCOPE EXPERIMENT PROGRAM (LTEP). VOLUME 1, PART 2
Perkin-Elmer Corp., Norwalk, Conn., Optical Group, 24 Apr. 1970, 512 p., refs. (Contract NAS8-21497) (NASA-CR-102769; Rept-9800-Vol 1-Pt 2) Avail:TAC

Summaries are given for optical technology experiments, superresolution and apodizing with segmented active optics, telescope thermal considerations, heat pipe feasibility, non-space experiments, image tubes, the Echelle spectrograph, the use of vidicons in astronomy, and current problems in infrared astronomy.

70038 HEAT PIPES--A COOL WAY TO COOL CIRCUITRY
C. H. Dutcher, Jr. and M. R. Burke (Electronic Communications, Inc., St. Petersburg, Fla.). Electronics, vol. 43, Feb. 16, 1970, p. 94-100, Avail:TAC

Discussion of the main design and operation features and applications of heat pipes. Waste heat removal in electronic devices, or also temperature leveling, is their main function. Sometimes the auxiliary function of providing structural support to the electronic components whose heat they remove is incorporated in their design. Vapor heat transfer and capillary action are their basic operational principles. Their operating temperature scope ranges from -200 to +2000 deg C, and the variety of fluids used runs from liquid nitrogen to liquid lithium or even silver. Their axial heat flux reaches above 25 kW per sq in. Superseding the bulkier fins and forced-air or liquid cooling systems, heat pipes substantially contribute to smaller packaging. The uses made of these thermal-conductance devices by various research organizations and manufacturers are reviewed. The interconnection methods used to form heat pipe systems are discussed.

70039 A SURVEY OF COOLING TECHINQUES FOR AIRCRAFT ELECTRONIC EQUIPMENT
S. A. Casazza and R. J. Joachim (Raytheon Co., Bedford, Mass.). In: New visions in electronic packaging in the 70's; Institute of Electrical and Electronics Engineers, Eastern Electronics Packaging Conference, Massachusetts Institute of Technology, Cambridge, Mass., June 8, 9, 1970, Proceedings. (A70-36758 18-09). New York, Institute of Electrical and Electronics Engineers, Inc., 1970, p. 5.2.1-5.2.14, Avail:TAC

Discussion of avionics cooling techniques based on the heat transfer mechanisms of natural convection, forced convection, phase change (boiling and heat of fusion), and heat pipes. Present and near future aircraft electronics are processing more power than ever before. Equivalent or shrinking space allocations require greater packaging density resulting in increased heat flux for components such as microelectronics, large-scale integrated circuits, and other solid-state devices. Hot spot power densities of 100 to 1000 watts per cubic inch have become commonplace in advanced electronics. As a result, the heat removal process and temperature control techniques have become challenging design problems. Current avionics cooling systems and some state-of-the-art concepts that may have future application are discussed with the intent to examine the range of thermal design approaches available to the designer.

70040 AN ANALYSIS OF THE HEAT PIPE AS A HEAT SINK FOR SOLID-STATE R.F. SOURCES
Wilson, W. E., IEEE Trans. Electron Devices (USA), vol. ED-17, No. 11, p. 1013-14 (Nov. 70), Avail:TAC

Equations are developed for determining the temperature of a steady state power flux source incident on the heat pipe as a function of the pipe wall thickness. The analysis shows the heat pipe to be no better than a semi-infinite heat sink operating at an elevated temperature for practical solid-state r.f. devices having power flux densities of 10^4-10^6 watts/cm^2.

71016 MICROWAVE POWER RECEIVING ANTENNA
National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala., Patent, Carroll C. Dailey, inventor (to NASA). Issued 20 Oct. 1970. (Filed 1 May 1969), 7 p. Cl. 307-149; Int. Cl. HO2j1/OO (NASA-Case-MFS-20333; US Patent 3,535, 543: US Patent Appl SN-820965) Avail:TAC

A microwave power receiving antenna is described having a solid state rectifier circuit comprising a plurality of diodes which converts high frequency energy to direct current. Each enclosure and its corresponding pair of dipoles is mounted on a heat conducting support post, which in turn is mounted on a large antenna reflector. The device effectively solves the problem of heat dissipation by constructing the dipole supporting posts, the antenna reflector, and the dipole elements as heat pipe devices. Each supporting post and the antenna reflector may either communicate for greater efficiency in dissipating heat or be physically separated to simplify fabrication. Brief descriptions accompany drawings of the antenna.

71017 CAPACITOR ENERGY STORAGE IMPROVEMENT BY MEANS OF HEAT PIPE
Eberhart Reimers (U.S. Army, Mobility Equipment Research and Development Center, Fort Belvoir, Va.). In: Power Sources Symposium, 24th, Atlantic City, N.J., May 19-21, 1970, Proceedings. (A71-13026 03-03). Symposium sponsored by the U.S. Army, Red Bank, N.J., PSC Publications Committee, 1970, p. 118-122, Avail:TAC

Analysis of the application of bidirectional heat exchange capability in order to thermally stabilize the capacitance of large capacitor banks over a wide temperature range. A quantitative analysis is given in terms of heat loss vs conducted heat, where the losses are expressed in terms of component geometry and the dielectric constant. The results show that the attachment of the capacitor to an infinite heat sink by means of a heat pipe will significantly reduce the bulk and weight of capacitors, and component reliability will be enhanced.

C. HEAT PIPE THEORY

C.1 GENERAL THEORY

65013 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING APRIL 30, 1965
Los Alamos Scientific Lab., Univ. of California, N. Mex., May 1965. (LA-3316). Contract W-7405-eng-36. 49p., Avail:TAC

Results of a LAMPRE transfer function review is presented along with a discussion of fuel testing in Omega West Reactor Experiment. Component design and development for the Fast Reactor Core Test Facility is summarized. Supporting research and development are reported on activation determination of O_2, reactor blanket systems, Pu alloys and cermets, Los Alamos Turret Reactor, Plasma thermocouples, and heat pipes.

66017 ANALYSIS OF LOW-TEMPERATURE DIRECT-CONDENSING VAPOR-CHAMBER FIN AND CONDUCTING FIN RADIATORS
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Henry C. Haller, Bruce G. Lindow, and Bruce C. Auer, Washington, NASA, Nov. 1965, 59 p., refs., Avail:TAC. (NASA-TN-D-3103)

An analytical comparison of flat, direct-condensing finned-tube space radiators using vapor-chamber, double, and central fin-tube geometries was made for a low power output, low temperature Rankine space power electric generating system. Descriptive equations for the radiator investigation included consideration of vapor and liquid headers, pressure drop in headers and radiator tubes, meteoroid protection, and temperature drop in tube armor. Heat transfer, weight, and geometry characteristics of the three radiator fin-tube configurations were determined over a wide range of design variables for a 30-kilowatt powerplant that used steam as the thermodynamic cycle fluid. Thermal degradation of the vapor chamber fin-tube radiator due to fin-segment punctures, and the vapor chamber heat transfer and capillary fluid flow requirements were also investigated. Radiator geometry considerations indicated that, at the minimum weight, the vapor chamber fin-tube radiator had a smaller planform area, fewer radiator tubes, and larger tube inner diameters than the other two fin-tube geometries.

66018 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING JULY 31, 1965
Los Alamos Scientific Lab., Univ. of California, N. Mex., Aug. 1965. Contract W-7405-eng-36. 61 p., (LA-3370), Avail:TAC

Progress on construction of the Fast Reactor Core Test Facility is reported. Descriptions are included concerning construction of the building and associated services, installation of a 20-Mw Na coolant system, installation of a control room, and construction of the reactor. Information is also included on design of a molten Pu burnup experiment and fuel testing in the Omega West Reactor. Data are included from accelerated fuel corrosion tests, mass transfer of Ta in molten fuel alloys, and preparation of UCl_3-KCl-NaCl for blanket studies. Efforts devoted to research on Na purity, venting fission gases in Na coolant, and Na-fuel equilibria are discussed. Research is summarized on properties of Pu carbides, U_2C_3-Pu_2C_3 systems, Pu nitrides, and Pu-Sc alloys. Progress on construction and component testing the UHTREX program is summarized, along with research on plasma thermocouples and heat pipes.

66019 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING OCTOBER 31, 1965
Los Alamos Scientific Lab., Univ. of California, N. Mex., Nov. 1965. Contract W-7405-eng-36. 65 p., (LA-3431), Avail:TAC

Further development in the components of the proposed Fast Reactor Core Test Facility is reported. Results from fuel capsule testing in the Omega West Reactor are presented. The containers were carbonized and noncarbonized Ta and Ta-W alloys. The fuel was Ce-Co-Pu alloys. Research on plutonium fuels is discussed. Various properties of the fuels are given. Further developments in the Turret Reactor are reported, and also research on a plasma thermocouple is discussed.

66020 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING JANUARY 31, 1966
Los Alamos Scientific Lab., Univ. of California, N. Mex., Feb. 1966. Contract W-7405-eng-36. 64 p., (LA-3482), Avail:TAC

Further developments in construction of the Fast Reactor Core Test Facility (FRCTF) are reported. Preliminary calculations for the Molten Plutonium Burnup Experiment (MPBE) are given. The corrosive effects of molten Pu alloys on Ta and Ta-W fuel capsules are presented. The results are also presented for carburized fuel capsules. Sodium technology and other supported research to be used in conjunction with the MPRE are included.

66021 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING APRIL 30, 1966

Los Alamos Scientific Lab., Univ. of California, N. Mex., May 1966. Contract W-7405-eng-36. 68 p., (LA-3524), Avail:TAC

Further developments in the various components of the Fast Reactor Core Test Facility are described. Some of the cores of the FRCTF are briefly described. Containers for the molten Pu-Co-Ce fuels were tested. Corrosion tests were made on carburized and uncarburized Ta, Ta-W, Ta-W-Y, Nb-Zr, and Nb-W alloys. The tensile properties of uncarburized and carburized Ta-W alloys are given. Burst tests were made on several of the containers. Other brief discussions of various supporting research are presented.

67034 STATUS OF THE ENGINEERING THEORY OF HEAT PIPES
Los Alamos Scientific Lab., N. Mex., T. P. Cotter. In: Sandia Corp. Proc. of Joint AEC/Sandia Lab., Heat Pipe Conf., Vol. 1, Oct. 1966, p. 5-9 (see N67-26791 14-33), Avail:TAC

The current theory for design and performance analysis of heat pipes is summarized briefly, and the principal areas limiting their development are discussed.

67035 OPERATING LIMITS OF THE HEAT PIPE
North Carolina State Coll., Raleigh, A. Carnesale, J. H. Cosgrove, and J. K. Ferrell. In: Sandia Corp. Proc. of Joint AEC/Sandia Lab. Heat Pipe Conf., Vol. 1, Oct. 1966, p. 27-44, refs. (see N67-26791 14-33), Avail:TAC

The rate at which heat can be transferred through a given heat pipe may be limited by one or more of the following considerations: evaporator heat transfer area; condenser heat transfer area; and capacity of the capillary pump. Reported are studies concerned with heat pipes limited by the last of these considerations. An analytical model of the heat pipe is presented. The model, based upon basic mass, energy, and momentum balances, is solved to yield an expression for the maximum heat transfer rate. Experiments resulting in data suitable for testing this model are described and the close agreement between analysis and experiment is demonstrated.

67036 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
Progress Report, January 1-June 30, 1967. Ferrell, J. K.; Carnesale, A. (North Carolina State Univ., Raleigh). July 1, 1967. Contract AT(40-1)-3411. 29 p., Avail:TAC

Work performed from January 1, 1967, through June 30, 1967, on the following is reported: operation of a stainless steel heat pipe at increased power levels and with several different wick bead sizes, heat pipe analysis, investigation of heat transfer through porous media, design of a controlled environment heat pipe experiment, and investigation of the fundamental aspects of capillarity.

67037 EVALUATION OF THEORETICAL HEAT PIPE PERFORMANCE
Ernst, D. M., Thermo Electron Corp., Waltham, Mass. 6th Thermionic Conversion Specialists Conf., Palo Alto, Cal., Oct. 1967. Avail:TAC (6p), 9 refs.

The heat pipe has been established as a thermal energy transfer device with many practical applications. However, the engineer who must design a heat pipe is confronted with numerous theoretical and experimental papers giving various results. The aim of this paper is to provide the engineer with a method for designing a heat pipe within the constraints of a system without the need for extensive parametric experiments.

67038 OPERATING CHARACTERISTICS OF CAPILLARITY-LIMITED HEAT PIPES
Cosgrove, J. H., Ferrell, J. K., Carnesale, A., J. Nuclear Energy v 21 n 7 July 1967 p 547-58 Avail:TAC

Heat pipe is cylindrical in shape, has annular porous wick, and consists of evaporator, adiabatic and condenser sections; in steady-state operation heat is added at evaporator section by conduction through wall, resulting in vaporization of convective fluid at wick surface and flow of vapor toward condenser end through hollow central region; heat is removed at condenser section by conduction through wall, resulting in condensation of vapor at wick surface; condensate returns to evaporator section by capillary flow through wick; many promising applications appear to be in space systems.

67063 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION/SANDIA LABORATORIES HEAT PIPE CONFERENCE HELD AT ALBUQUERQUE, NEW MEXICO, JUNE 1, 1966. VOLUME I.
Sandia Corp., Albuquerque, N. Mex., Oct. 1966. Contract AT(29-1)-789. 91p. SC-M-66-623. (CONF-660645), Avail:TAC

The conference was divided into two sessions during which papers discussing theoretical analyses, development procedures, and a variety of applications for heat pipes were presented. Volume II contains the classified papers. Topics covered in Volume I include status of the engineering theory of heat pipes, heat pipe capability experiments, operating limits of heat pipes, liquid transport and heat transfer properties of heat pipe wicking materials, feasibility studies of space radiators using vapor chamber fins, and heat pipes and vapor chambers and their application to thermal control of spacecraft.

68025 SOME OPERATING LIMITS ON HEAT PIPES
Werner, R. Lawrence Rad. Lab., U. of Calif., Livermore Space Power Note No. 293 (April 3, 1968) Avail:TAC (8p), 2 refs.

Reasonable approximations for the values of ΔT to produce nucleate boiling in heat pipe wicks for various liquid metals are provided. Some rather general comments on sonic velocity of the heat pipe vapor and entrainment of the liquid in the vapor are made.

68026 HEAT PIPE CAPABILITY EXPERIMENTS
Kemme, J. E., IEEE-Thermionic Conversion Specialist Conference--Conference Rec Nov 3-4 1966 p 159-68 Avail:TAC

Axial heat transfer limits were determined for several heat pipe systems to show methods for increasing heat transfer capability and to check validity of existing heat pipe equations; measurements at operating temperatures from 450 to 850 C; sodium and potassium are used as working fluids; heat pipe preparation and construction techniques; pertinent fluid properties are plotted as function of temperature; heat pipe equations are listed and experimental results are compared with calculated heat transfer limits.

69060 HEAT PIPE RESEARCH IN EUROPE
C. A. Busse (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 461-475. 17 refs., Avail:TAC

Review of recent work done on heat pipes in West-European laboratories, with emphasis on (1) the heat quantities that can be transported by means of a heat pipe, (2) the maximum heating rate, and (3) the lifetime of a heat pipe. Research results show that heat pipes make it possible to transport large quantities of heat with practically no temperature drop; heat transport rates up to 15 kW/cm^2 have been measured. There seems to be a good chance of finding ductile heat pipe systems with a lifetime of much more than 1000 hr, even at 1600°C.

69061 PRELIMINARY RESULTS OF A STUDY OF HEAT PIPES AT HIGH TEMPERATURE [RESULTATS PRELIMINAIRES D'UNE ETUDE SUR LES CALODUCS A HAUTE TEMPERATURE]
M. Armand and A. M. Shroff (Compagnie Générale de Télégraphie Sans Fil, Groupement Scientifique et Technique, Orsay, Essonne, France). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 557-563. In French, Avail:TAC

Consideration of the application of heat pipes for the transfer of the heat of vaporization of fluids without loss of heat for the case of high temperatures, particularly for heating the emitters of thermionic converters. This mode of heating provides excellent homogeneity of emitter temperature, and the possibility of separating the heat source from the diode, which is of interest in the case of nuclear heating. Some theoretical results obtained for the optimization of the capillary system, as well as the thermal resistance to be expected, are given. Experimental apparatus used to evaluate the performance of heat pipes is described. In a technological study, the materials utilized, the housings and heat carriers, methods of developing and forming heat pipes, and lifetime tests are discussed.

69062 TWO-COMPONENT HEAT PIPES
C. L. Tien (California, University, Berkeley, Calif.). American Institute of Aeronautics and Astronautics, Thermophysics Conference, 4th, San Francisco, Calif., June 16-18, 1969, Paper 69-631. 7 p., Avail:TAC

Study of the operational characteristics of two-component heat pipes. A qualitative description is given on the basis of the thermodynamic phase equilibrium for binary mixtures. The present physical model differs in several fundamental aspects from the existing one in the literature. The experimental results obtained from a water-ethanol heat pipe under various operating conditions lend direct support to the present physical model.

69063 ANALYSIS OF TEMPERATURE DISTRIBUTIONS IN HEAT PIPE WICKS
F. A. Lyman and Y. S. Huang (Case-Western Reserve University, Div. of Fluid, Thermal, and Aerospace Sciences, Cleveland, Ohio). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-23. 11 p., 16 refs., Avail:TAC NASA-supported research

Heat pipes are generally regarded as constant-temperature devices because the axial temperature drop in the vapor is small even at high heat transfer rates. Large axial temperature gradients do occur in the wicks of heat pipes using water, however. This work presents exact analytical solutions for the two-dimensional problem of liquid flow and heat conduction within the wick. The predicted axial temperature drops agree with values measured by other workers at low heat fluxes but are too large at high heat fluxes. The theory predicts large axial temperature gradients when liquids of low thermal conductivity are used in heat pipes. The theory also clarifies the nature of certain singularities which may prevent convergence of finite-difference techniques presently being applied to this problem.

69064 ANALYTICAL AND EXPERIMENTAL STUDY OF SODIUM HEAT PIPES
Semeria, R.; Schmidt, E. (CEN, Grenoble, France). Bull. Inform. Sci. Tech. (Paris), No. 132, 31-48 (Dec. 1968). (In French).

The results obtained in the course of theoretical and experimental studies carried out on sodium heat pipes, the capillary structure of which is made up of square-mesh sieves are discussed. The chief aim of this work was to determine the thermal power limit of the apparatus as a function of several parameters, with special reference to the specifications of the capillary network.

69065 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE. PART I. AN ANALYTICAL MODEL FOR THE PREDICTION OF OPERATING LIMITS OF HEAT PIPES. PART II. CAPILLARITY IN POROUS MEDIA
Ferrell, J. K.; Cosgrove, J. H.; Carnesale, A.; Schoenborn, E. M. (North Carolina State Univ., Raleigh. School of Engineering). Final Report (ORO-3411-12 (Pts. 1 and 2)), Apr. 30, 1969. Contract AT-(40-1)-3411. 50 p., Avail:TAC

An analytical model is presented based on fundamental mass, heat, and momentum balances in the wick. It relates the maximum heat input to the fluid and wick characteristics and to the inclination of the pipe with respect to gravity. The model indicates that the critical parameters and operating characteristics are the capillary forces in the wick, pressure drop through the wick, and the operating temperature of the heat pipe. Maximum heat inputs in two experimental heat pipes were determined using packed beds of monel particles as wicking material and water as the working fluid. The agreement between the experimental results obtained and those predicted using the analytical model was excellent.

70041 INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE, VOLUME 1
Kansas State Univ., Manhattan., Dept. of Mechanical Engineering, Paul L. Miller and Francis W. Holm, Final Report, Sep. 1967-Sep. 1969, Dec. 1969, 107 p., refs. (Contract F33615-68-C-1017) (AFFDL-TR-69-91-Vol-1), Avail:TAC

The studies described in the report clarify the effects of some of the limitations imposed by the laws of thermal similitude, and determine the thermal modeling laws for a heat pipe. In Volume 1 solutions were presented for the steady-state temperature distribution and heat transfer in a radiating fin having temperature dependent thermal conductivity. Using these solutions, modeling prediction errors were determined for fin type prototype/model systems with dimensional distortions, with material having temperature dependent thermal conductivity, and with low prototype temperatures. In volume 2 the thermal modeling laws for a heat pipe were derived and experimentally verified. A flexible heat pipe was also designed and experimentally tested.

70042 INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE, VOLUME 2
Kansas State Univ., Manhattan, Dept. of Mechanical Engineering, Paul L. Miller and Francis W. Holm, Final Report, Sept. 1967-Sept. 1969, Dec. 1969, 100 p., refs. (Contract F33615-68-C-1017) (AFFDL-TR-69-91-Vol-2), Avail:TAC

The studies described clarify the effects of some of the limitations imposed by the laws of thermal similitude, and determine the thermal modeling laws for a heat pipe. In Volume II the thermal modeling laws for a heat pipe were derived and experimentally verified. It was observed that prototype thermal behavior could be predicted, from model data, to within 10 F over the temperature range tested (140 to 330 F). Heat pipe failure due to capillary failure was also predictable to within plus or minus 10%. A flexible heat pipe was also designed and experimentally tested. Performance was not degraded under conditions of bending.

70043 AN ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF ROTATING, NON-CAPILLARY HEAT PIPES
Naval Postgraduate School, Monterey, Calif., P. J. Marto, T. J. Daley, and L. J. Ballback, Annual Report, 30 Jun. 1970, 49 p., refs. (NASA Order W-13007) (NASA-CR-112657; NPS-59MX70061A), Avail:TAC

An analytical review of the operation of rotating, non-capillary heat pipes is presented, including a discussion of film condensation on the inside of a rotating, truncated cone. Predicted results so far obtained indicate that the heat transfer capability of rotating, non-capillary heat pipes depends upon condenser performance and is substantially higher than the capability of conventional, wick-limited heat pipes. The design and manufacture of an experimental rotating heat pipe apparatus is also described.

70044 ON THE EFFECTS OF CAPILLARY GEOMETRY ON OPTIMAL HEATING SURFACE LOADS IN HEAT PIPES [ZUM EINFLUSS DER KAPILLARGEOMETRIE AUF DIE MAXIMALE HEIZFLAECHENBELASTUNG IN WAERMEROHREN]
Technische Hochschule Stuttgart (West Germany), Konrad Moritz (Ph.D. Thesis), 27 Oct. 1969, 107 p., refs. In German. Avail:TAC

Possible limitations of energy transfer in heat pipes are studied with fluids of low thermal conductance and boiling retardation. Experiments with several capillary pipe structures indicate that open grooves attain the highest possible surface heat loads. A newly developed heat pipe with threaded arteries obtains high heat loads even at considerable bubble formation in the grooves; gravitational direction does not effect its heat flow. Equations for calculating maximum surface heat loads in open grooves are included and describe temperature as well as pressure effects on heat transfer.

70045 EFFECT OF MAGNETIC FIELDS ON HEAT PIPES
Gustav A. Carlson (California, University, Livermore, Calif.) and Myron A. Hoffman (California, University, Livermore and Davis, Calif.). In: Space systems and thermal technology for the 70's; American Society of Mechanical Engineers, Space Technology and Heat Transfer Conference, Los Angeles, Calif., June 21-24, 1970, Proceedings. Part 2. (A70-41014 21-33). New York, American Society of Mechanical Engineers, 1970, 11 p., 16 refs. AEC-sponsored research, Avail:TAC

Heat pipes have been proposed for use in environments where there are strong magnetic fields, as in controlled fusion reactors. The presence of a magnetic field can influence the performance of a heat pipe significantly, depending on the heat-pipe geometry, its orientation in the magnetic field, the heat-pipe materials and fluid properties as well as the magnetic field strength. A liquid-metal heat pipe, specifically designed to operate in a magnetic field, will employ a compound wick structure with the optimum liquid flow passage size larger and the vapor flow passage proportionately smaller than for the nonmagnetic field design. The basic conclusion is that the presence of a magnetic field always results in a lower maximum heat flux capability, but the detrimental effects of the magnetic field can be greatly reduced by using a heat-pipe geometry optimized for operation in the specific magnetic field environment.

70046 THERMAL SCALE MODELING OF A HEAT PIPE
Holm, F. W., Texas A & M Univ., Miller, P. L., Kansas State U. (ASME 70-HT/SpT-14. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (9p), 6 refs.

A parametric study of the defining equations for heat-pipe operation (i.e. energy, momentum, and continuity) was performed for the purpose of providing a method for predicting the performance characteristics of a heat pipe from the experimental behavior of a dimensionally and thermally similar (model) heat pipe. Two specific modeling techniques considered in this paper are (a) a technique preserving materials between model and prototype, and (b) a technique maintaining the same heat flux in both model and prototype. The similarity relations for the first modeling technique (material preservation) were verified by experiment and the similarity relations for the second modeling technique (heat flux presentation) are presented without experimental verification.

70047 PARAMETERS FOR THE ASSESSMENT OF HEAT CARRIERS IN HEAT PIPES
Groll, Manfred; Zimmerman, P. (Inst. Kernenerg, Univ. Stuttgart, Stuttgart, Ger.). Chem-Ing-Tech. 1969, 41(24), 1294-1300 (Ger), Avail:TAC

A fundamental equation for heat pipes is derived from a pressure balance and is used for direct estn. of the characteristic dimensions for max. possible axial transport of heat. A total of 5 limits for the operational efficiency of heat pipes could be detd. by phys. and chem. phenomena; these limits are closely investigated to achieve a qual. comparison of various heat carriers. Metals whose vapor consists of monat.

mols. can be used as high-temp. heat carriers. H_2O, NH_3, or Freon, which as a rule possess =3 atoms in the vapor mol, are suitable as low-temp. heat carriers.

70048 HEAT PIPE OF NEW CONSTRUCTION. THREADED ARTERY HEAT PIPE (EIN WAERMEROHR NEUER BAUART - DAS GEWINDE-ARTERIEN-WAERMEROHR)
Moritz, K. (Institut fur Kernenergetik der Universität Stuttgart, West Germany); Chemie-Ingenieur- Technik v 41 n 1-2 Jan 17 1969 p 37-40 (in German, transl. avail.) Avail:TAC

Principal difference between threaded arterial heat pipe and other heat pipes is that in former various capillary structures are used for return transport of condensate and its distribution over hot zone; the use of threaded arterial heat pipes offers advantages if large axial heat flows are to be transferred with simultaneous high radial heat transfer per unit surface; ease of manufacture offers further advantage over other types of heat pipes.

70049 LIMITATIONS OF ENERGY TRANSPORT IN HEAT PIPES (GRENZEN DES ENERGIETRANSPORTS IN WAERMEROHGREN)
Moritz, K. (Institut fur Kernenergetik der Universität Stuttgart, West Germany), Pruschek, R.; Chemie-Ingenieur-Technik v 41 n 1-2 Jan 17 1969 p 30-7 (in German, transl. avail), Avail:TAC

Equations for calculation of maximum possible transport by heat pipes and stipulations for their use are given; by way of example it is shown that arterial heat pipes (heat pipes of second generation) possess considerably greater transport possibilities than heat pipes of first generation, in which the core is made up of grooves or of several layers of gauze; experiments carried out for measuring critical heat flow density in hot zone are also discussed.

71018 THERMAL SCALE MODELING OF A HEAT PIPE
Kansas State Univ., Manhattan, Francis Wilford Holm (Ph.D. Thesis), 1969, 82 p., Avail: TAC

A thermal scale modeling program was instituted for the purpose of providing a method for predicting the performance characteristics of a heat pipe from the experimental behavior of a dimensionally and thermally similar (model) heat pipe. The equations for two specific modeling techniques, a technique preserving materials between model and prototype and a technique maintaining the same heat flux in both model and prototype, are derived. The similarity relations for the first modeling technique (material preservation) were verified by experiment and the similarity relations for the second modeling technique (heat flux preservation) are presented without experimental verification. Experiments were performed with two heat pipes (one model and one prototype) fabricated from identical materials. These heat pipes were tested in a high vacuum, cold wall environment without simulated solar, planet, or albedo radiation. Separate experiments were performed on the same two heat pipes to investigate the pumping capabilities of the wick.

71019 MATHEMATICAL MODELING OF CRYOGENIC HEAT PIPES
Catholic Univ. of America, Washington, D.C., Dept. of Space Science and Applied Physics, S. W. Chi, Sep. 1970, 123 p., refs. (Grant NGR-09-005-071) (NASA-CR-116175) Avail:TAC

A qualitative investigation of the performance of heat pipes using different working fluids was made, and the significance of liquid property variations on the performance of cryogenic heat pipes is described. A theory is developed for the cryogenic heat pipe which takes into account the liquid property variations. Predictions by the present theory compare favorably with Haskin's experiments. A computer program in Fortran IV language was written for the theory. Physical properties of cryogenic fluids, which are required as program input data are collected. For convenience of the user of the theory, a complete listing of the program with user's instructions and collected properties of cryogens are appended to the report. A chart is presented of the complete performance of cryogenic heat pipes. A procedure for computer aided design of cryogenic heat pipe is also described. The procedure consists of the following steps: (1) choice of fluid and wick structure, (2) determination of wick dimensions, and (3) generation of performance chart for the designed heat pipe.

C.2 HEAT TRANSFER

63001 BOILING HEAT TRANSFER AND MAXIMUM HEAT FLUX FOR A SURFACE WITH COOLANT SUPPLIED BY CAPILLARY WICKING
Costello, C. P., Redeker, E. R. (Chemical Engineering Progress Series, Vol. 41, 1963) Avail:TAC (10p), 6 refs.

Experimental results are presented for boiling heat transfer to ethanol from a stainless steel heater surrounded by a capillary wicking material. The ability of the wicking to convey coolant to a heater when the liquid level is such as to expose part of the heater is demonstrated. The effect of small accelerations directed normally toward the heater surface is studied. It is concluded that the full capabilities of capillary wicking to supply coolant to a heater cannot be realized without proper venting of vapor produced by boiling. Some recently obtained data are presented for a surface supplied with water by capillary action. In obtaining these data proper venting was employed and extremely high heat fluxes were obtained, substantiating the conclusions of this paper.

64001 STRUCTURES OF VERY HIGH THERMAL CONDUCTANCE
G. M. Grover, T. P. Cotter, and G. F. Erickson, Los Alamos Scientific Laboratory, J. of Appl. Physics, v. 35, June 1964 (1990-91) Avail:TAC (2p)

Description of the construction and operation of several simple devices for the transfer of a large amount of heat with only a small temperature drop. Within certain limitations on the manner of use, a heat pipe is regarded as a synergistic engineering structure with a thermal conductivity greatly exceeding that of any known metal. Included are test data from two liquid sodium heat pipes.

64002 ROLES OF CAPILLARY WICKING AND SURFACE DEPOSITS IN ATTAINMENT OF HIGH POOL BOILING BURNOUT HEAT FLUXES
Costello, C. P., Frea, W. J., A.I.Ch.E., J v 10 n 3 May 1964 p 393-8 Avail:TAC

Data show how burnout heat flux varies with presence of capillary wicking, surface deposits, and heater size; surface deposits which improve wettability can produce two- to three-fold increases in burnout heat flux; Fiberglas wicking provides surface deposit improving wettability.

66022 ON THE PERFORMANCE OF A HEAT PIPE
D. K. Anand (Johns Hopkins University, Applied Physics Laboratory, Space Development Div., Silver Spring; Maryland, University, College Park, Md.). Journal of Spacecraft and Rockets, vol. 3, May 1966, p. 763-765.

Description of a heat pipe which is a self-contained device exhibiting a very high effective thermal conductivity. The heat pipe consists of a vapor core and a fluid annulus (fluid flowing through the wick). As an extension to a previous study, the heat-transfer coefficients in the evaporator section are correlated, giving a rather good indication of the engineering performance. Experiments have been performed to show the temperature distribution, the boiling heat-transfer coefficients, and the vapor temperature and pressure drop. The wick boiling heat-transfer correlation is plotted, and it is confirmed that wick boiling is preferable at low heat fluxes. The temperature distribution on the heat pipe is plotted. The results indicate the potential usefulness of the heat pipe.

67039 THEORETICAL CONSIDERATIONS ON HEAT TRANSFER IN HEAT PIPES
M. Schindler and G. Woessner (Tech. Hochsch. Stuttgart, Ger.) Atomkern Energie 10(9), 395-8 (1965) (Ger), Avail:TAC

High heat transfer with small temp. drop may be obtained by evapg. a liquid coolant, transporting the vapor and subsequent condensation of the vapor. If the condensate is returned to the evaporator by capillary forces, there is no need of auxiliary systems such as pumps. For heat pipes operating on this principle, the phys. basis is discussed and heat transfer is calcd. based on an elementary model. A numerical example is given with regard to waste-heat transport from thermionic reactors.

68027 HEAT TRANSFER MEASUREMENTS USING SODIUM HEAT-PIPE WORKING AT LOW VAPOR PRESSURE
Bohdansky, J., Strub, H., Andel, E. van, IEEE--Thermionic Conversion Specialist Conference--Conference Rec Nov 3-4 1966 p 144-8 Avail:TAC

Maximum heat flow measurements on sodium-columbium heat-pipe were carried out in temperature interval from 500 to 800 C; measured values could be explained by theoretical model regarding gravitational forces in liquid phase and acceleration forces in vapor phase; heat-pipe was operated at different inclinations to measure surface tension of liquid; maximum heat flow equations are given and verified by experiments in laminar flow regions.

69066 PRESSURE BALANCE AND MAXIMUM POWER DENSITY AT THE EVAPORATION GAINED FROM HEAT PIPE EXPERIMENTS

F. Reiss and K. Schretzmann (Kernforschungszentrum Karlsruhe, Institut für Neutronenphysik and Reaktortechnik, Karlsruhe, West Germany). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 507-513. 11 refs., Avail:TAC

Heat-pipe experiments indicate that very high heat-flux densities can be removed from capillary lined evaporator surfaces. Data for the maximum attainable heat flux densities are derived from experiments, preferably with sodium-filled heat pipes. Hydrodynamic and gaskinetic calculations are presented which are in accordance with the measured data.

69067 VAPORIZATION HEAT TRANSFER IN CAPILLARY WICK STRUCTURES
Ferrell, J. K., Alleavitch, J. North Carolina State U. (AIChE Preprint 6 11th Nat'l Heat Transf. Conf. Aug. 3-6, 1969) Avail:TAC (16p), 6 refs.

The objective of the research here was to study the mechanism of vaporization heat transfer from wick covered, heated surfaces. Results for both normal operation (heat fluxes below the critical), and critical heat fluxes will be presented. The critical heat flux as used here is that value of the heat flux at which drying of the wick occurs and a large increase in the heated surface temperature is observed. In this sense, it is similar to the same term applied to ordinary pool boiling. The experimental configuration (flooded, wick covered surfaces) is not typical of heat pipe operation and is appropriate only for a study of the mechanism of the process.

70050 A SHORT STUDY OF CAPILLARY ACTION IN BOILING WATER HEAT TRANSFER THROUGH POROUS MEDIA
Central Electricity Generating Board, London (England). Research and Development Dept., A. A. Stratton and W. N. Walker, Jul. 1969, 17 p. (RD/B/N-1358) Avail:TAC

Experiments were carried out to test the proposal that a boiling process involving capillary action occurs when porous layers are built up between a heat transfer surface and its liquid coolant. A theoretical model was also set up and compared with the experimental results. Tests with real porous media were inconclusive owing to poor thermal contacts. Experiments with a single capillary indicated that boiling within pores was explosive owing to restricted bubble expansion, and was only well predicted by the theory when the resulting meniscus movement was small. This condition is expected to hold in porous media, and, by application of the theory to these, it was found that this process may provide an efficient heat transfer mode.

70051 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE, PART IV. HEAT TRANSFER IN THE EVAPORATOR ZONE OF A HEAT PIPE
Ferrell, J. K.; Johnson, H. R. (North Carolina State Univ., Raleigh. School of Engineering). Final Report, Apr 1969. Contract AT(40-1)-3411. 150p. (ORO-3411-12 (Pt. 4)), Avail:TAC

The heat transfer mechanism in the evaporator section of a heat pipe was studied. Since several operating features of a typical heat pipe tend to complicate an experimental investigation of the heat transfer phenomena in the evaporator section, a controlled environment heat pipe was designed and operated. This controlled environment heat pipe was divided into an adiabatic section and an evaporator section. Both sections consisted of a rectangular duct which was completely filled with small particles to form a porous wick. One end of the adiabatic section was immersed in a pool of the working fluid which flowed by capillary action to the evaporator section where it was vaporized. The upper surface of the wick in this section was uncovered to permit disengagement of the vapor. The heat pipe was wholly enclosed within a flanged glass pipe which was filled, during operation, with vapor from an auxiliary pool of the working fluid to provide a constant temperature and pressure environment. Experimental data were obtained to determine the relationship between heat flux and temperature difference between the heated surface and the wick and to determine the limiting operation conditions. The heat flux-temperature difference data were obtained at atmospheric pressure using water as the working fluid and monel and glass particles for the wick. Data on the limiting operating conditions were obtained for monel particles using the same working fluid and at the same pressure. The particles ranged in size from 149 to 590 microns and the heat flux range was from 1,500 to 80,000 Btu/hr-ft^2. Based on initial data, a mechanism to describe the heat transfer phenomena was proposed which considered that heat transfer from the heated surface occurred by conduction with vaporization of the liquid occurring at vapor-liquid interfaces located in the layer of particles covering the surface, and that the critical heat flux was obtained when the capillary forces were no longer sufficient to keep a major part of the heated surface wet. Based on this proposed mechanism, theoretical expressions were developed for predicting an over-all heat transfer coefficient and the critical heat input. The agreement between the predicted and experimental values of the over-all heat transfer coefficient was excellent for normal conditions of the wick and the normal operating range. Even when the wick conditions were not normal, i.e., the bottom layers of particles fused to each other and to the heated surface, the proposed mechanism of heat transfer by conduction was still valid even though the predicted values were larger than the experimental ones. Also, it was shown that the upper limit of the normal operating range could be predicted and depended upon the limits of the particle size range used for the wick and the critical heat flux. The agreement between the predicted and experimental values for the critical heat flux was excellent when proper values were selected for the cross-sectional areas for vapor and liquid flow in the evaporator section. The selection of these values was necessary since no theoretical or experimental method was developed for predicting them.

70052 HEAT TRANSFER FROM THE WALL OF A POROUS SOLID INVOLVING GAS INJECTION AND VAPORIZATION
W. J. Frea, J. H. Hamelink, Journal of Heat Transfer, Feb. 1970 (153-58), Avail:TAC (6p), 13 refs.
An experimental study was made of heat transfer with gas injection through a porous wall into a pool of liquid, including vaporization effects. Air bubbling from the surface of a graphite cylinder into water at atmospheric pressure was used. It was possible to determine limits on energy transfer due to convection and to latent heat transport. It was found that under some conditions it was possible to operate the system with the surface rejecting heat while at temperatures less than that of the bulk pool liquid.

70053 THEORY OF THE SONIC HEAT TRANSFER LIMIT OF HEAT PIPES
C. A. Busse, Euratom CCR, 21020 Ispra, Italy. Avail:TAC (17p)
The sonic heat transfer limit of cylindrical heat pipes is analyzed by a perturbation method assuming a two-phase equilibrium vapor and taking into account the radial variation of the axial velocity. The velocity profile is determined from an approximate solution of the Navier-Stokes equation for the limiting case of predominant inertia forces. This profile proves to be flatter than in the corresponding case of incompressible flow. Formulas are derived for the average heat flux density at the sonic limit, for the average velocity and the average vapor quality at the evaporator exit, and for the ratio of pressure, temperature, gas density and average vapor density at the beginning and at the end of the heating zone. The values of the sonic heat flux density are respectively about 15% and 7% lower than those obtained by Levy from an ideal gas model and a two-phase equilibrium vapor model with the assumption of a rectangular velocity profile. The agreement between theory and experimental data for Na, K, Cs and Hg is very good, except for low temperature data of Na and K.

70054 EFFECTIVE THERMAL CONDUCTIVITY OF DRY AND LIQUID-SATURATED SINTERED FIBER METAL WICKS
Soliman, M. M., Graumann, D. W., Berenson, P. J., AiResearch Manufacturing Co., Los Angeles, Calif. (ASME 70-HT/SpT-40. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (10p), 9 refs.
Experimental data are presented for the effective thermal conductivity of dry and water-saturated sintered fiber metal wicks. The data were obtained both along and across the fibers. Semiempirical correlations have been obtained for the effective thermal conductivities in terms of the thermal conductivities of the solid and fluid phases and the void fraction.

70055 MAXIMUM HEAT TRANSPORT OF OPTIMALLY DESIGNED HEAT PIPES
Groll, Manfred, et al., Chem-Ing.-Tech. 1970, 42(15), 977-81 (Ger.) Avail:TAC 5p.
An account is given of the optimum design of 2nd generation heat pipes, particularly annular space heat pipes, with regard to max. heat transport capacity. The quantities of heat that can be transported are severely limited by such conditions as the heat transferred per unit surface and bubble formation. The diam. of annular-space heat pipes is also limited inter alia by the fact that the annular space must be filled completely against gravity. Whereas arterial heat pipes containing low-boiling heat carriers permit only low heat c.ds., spiral arterial heat pipes can be used up to 140 W/cm^2 with the same heat carriers.

70056 DETERMINATION OF BOILING FILM COEFFICIENT FOR A HEATED HORIZONTAL TUBE IN WATER-SATURATED WICK MATERIAL
Allingham, William D., and McEntire, Jack A. Journal of Heat Transfer, February 1961. Avail:TAC, 6 p.
Using an absorbent wick material saturated with a coolant has become attractive from a design standpoint for some missile-cooling applications. However, published

data for predicting film coefficients are very limited. In this study, boiling film coefficients for a 1.0-in. OD horizontal tube of copper embedded in water saturated ceramic fiber-wick material were correlated over a heat flux range from 1000 to 10,000 Btu per hr sq ft by the dimension equation

$$\left(\frac{h}{C\theta'}\right)\left(\frac{C\mu}{K}\right)^{0.6}\left(\frac{\rho_L\sigma}{P^2}\right)^{0.21} = 0.072\left(\frac{D_eG'}{\mu}\right)^{-0.77}$$

$$G' = \frac{Q}{A\varepsilon\lambda}$$

The presence of wick material next to a heat-transfer surface decreases turbulence in the region near the surface, increases the effective surface area, and provides active sites for bubble formation. This produces a higher film coefficient at low heat flux than occurs with pool boiling. At higher heat flux, the wick-boiling film coefficient was lower than for pool boiling.

71041 VAPORIZATION HEAT TRANSFER FROM FLOODED WICK
Alleavitch, J., Dept. of Chem. Engrg., North Carolina State University, Raleigh, 1969. (Ph.D. Thesis).

C.3 CONDENSATION AND EVAPORATION

60001 ON HYDRODYNAMIC BOUNDARY CONDITIONS FOR EVAPORATION AND CONDENSATION
Kucherov, R. Y., Rikenglaz, L. E. (Soviet Physics JETP Volume 37 (10), Number 1, January 1960) Avail:TAC (2p), 4 refs.

The boundary conditions have been found for hydrodynamic equations in the presence of evaporation and condensation. For small evaporation rates the temperature jump and the deviation of the vapor pressure from the equilibrium value are shown to be of the order of the ratio between the speed of the vapor flow v and the mean speed of heat transfer c. It is shown that the expressions commonly used in the literature for the flow of materials and heat in the presence of evaporation and condensation contain an error.

67040 EFFECTS OF CONDENSER PARAMETERS ON HEAT PIPE OPTIMIZATION
D. K. Anand, R. E. Jenkins (Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Md.), and A. Z. Dybbs. Journal of Spacecraft and Rockets, vol. 4, May 1967, p. 695, 696. NASA-supported research; Contract No. NOw-62-0604-c, Avail:TAC

Study of the maximum heat transport in heat pipes. It is indicated that the operation of heat pipes is constrained mostly by condenser parameters. The nonradiative type of condensers is discussed, and an application where the heat is radiated away from the exterior surface of the condenser is considered.

68028 THEORETICAL CONSIDERATIONS ON A VAPORIZATION COOLING SYSTEM WITH CAPILLARY DISTRIBUTOR [THEORETISCHE UEBERLEGUNGEN ZU EINER VERDAMPFUNGSKUEHLUNG MIT KAPILLAR-VERTEILER]
Deutsche Versuchsanstalt fur Luft- and Raumfahrt, Brunswick (West Germany). Inst. fuer Strahlantriebe, A. Quast, Dec. 1967, 23 p., refs. In German; English summary. (DLR-FB-67-85), Avail:TAC

Theoretical calculations are indicated for a cooling system utilizing the vaporization heat. In the same way as in "Heat-Pipes" the boiling liquid is kept on the heated surfaces by open capillaries. Mach-Number and critical-heat-flux do limit the heat transport. A nuclear reactor equipped with thermionic power converters is shown as an example for the efficiency of the cooling system. At 650°C with potassium the following results were obtained theoretically: Mach-Number of vapor less 0.3, temperature difference between reactor-core and reactor-brink less 5°C, pump-power about one hundredth of liquid-metal cooling circuit.

68029 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE: CAPILLARITY IN POROUS MEDIA Progress Report During the Tenth Quarter, 1 Oct.-31 Dec. 1967
North Carolina State Coll., Raleigh, J. K. Ferrell and E. M. Schoenborn, 20 Feb. 1968, 17 p., refs. (Contract AT(40-1)-3411), Avail:TAC (ORO-3411-10)

Falling capillary equilibrium heights of water in porous media were determined under adiabatic and evaporative (boiling) conditions at atmospheric pressure. The packed beds consisted of stainless steel particles (40 to 100 mesh) and glass beads (80 to 100 mesh). For the glass beads, capillary heights were correlated as a function of the specific evaporation rate of the working fluid and found to be independent of evaporation rate over the range (0 to 50 lb/hr-ft^2) studied. The data were explained by assuming that the sole effect of imposing a heat flux on the porous media was to change the surface tension and density of the liquid water. The effect of reduced surface tension and density alone were sufficient to explain the observed results; apparently no change in cost θ/τ was affected by the imposition of the heat flux.

69068 SPACE ELECTRIC POWER R AND D PROGRAM PART 1
Los Alamos Scientific Lab., N. Mex. Quarterly Status Report, Period Ending 31 Oct. 1968, 22 Nov. 1968, 6 p. (Contract W-7405-ENG-6) (LA-4039), Avail:TAC

Fluid pressure conditions which can occur with annular return heat pipes using cesium, mercury, potassium, or sodium as the working fluid are described, and calculated values are compared with experimental measurements.

69069 EFFECT OF NUCLEATE BOILING ON THE OPERATION OF LOW TEMPERATURE HEAT PIPES
P. J. Marto (U.S. Naval Postgraduate School, Dept. of Mechanical Engineering, Monterey, Calif.) and W. L. Mosteller. American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-24, 8 p., 11 refs., Avail:TAC

Study of the effects of nucleate boiling using an everted stainless steel heat pipe designed to permit visualization of the wick structure and of bubble nucleation during operation. Four layers of 100 mesh stainless steel wire cloth were used as the wick structure. Results were obtained with water and ethyl alcohol over a range of operating pressures from 25-in. Hg vacuum to 5 psig. A type of nucleate boiling was observed which did not affect the overall operation of the heat pipe.

69070 STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE. PART III. VAPORIZATION HEAT TRANSFER FROM FLOODED WICK COVERED SURFACES.
Ferrell, J. K.; Alleavitch, J. (North Carolina State Univ., Raleigh. School of Engineering). Final Report, Apr. 30, 1969. Contract AT(40-1)-3411. 158p., Avail:TAC

The mechanism of vaporization heat transfer on a system with a fluid-wick combination that had well-defined geometric parameters and physical properties has been examined. The experimental apparatus consisted of a horizontal, stainless steel surface with a bed of monel beads of various sizes and depths in contact with it. The beds were covered with 2- through 4-inch depths of distilled water. The experimental data indicated very strongly that, in contrast to ordinary pool boiling, the heat transfer coefficient was very nearly constant for all heat fluxes below the critical value and that the latter is reached when the capillary forces are no longer sufficient to maintain liquid in contact with the heated surface. Analytical models were derived for both the heat transfer coefficient and the critical heat flux and are shown to be in excellent agreement with the experimental results obtained.

70057 INVESTIGATION OF HEAT EXCHANGE WITH BOILING WATER DELIVERED TO THE HEATING SURFACE BY A CAPILLARY POROUS BODY AT LOW PRESSURES
National Lending Library for Science and Technology, Boston Spa (England), T. A. Kolach et al., 17 Dec. 1969, 18 p., refs. Transl. into English from Inzh.-Fix. Zh. (Moscow), v. 14, June 1968, p. 975-982 in English and Russian. (NLL-CE-Trans-5098-(9022-09)), Avail:TAC

The results of an experimental study of boiling water supplied to a heating surface by a capillary porous body within the pressure range 0.006 to 0.800 bar are presented. The presence of the capillary porous body on the heating surface facilitates vapor bubble formation even at small temperature values. The heat transfer intensity mainly depends upon the conditions of vapor removed from the heat transfer surface. With a particular heat load, a non-stationary heat transfer regime was observed, characterized by a continuous increase of the wall temperature. The effect of pressure decrease upon the heat transfer intensity is in its quality, the same as that at water boiling in a free volume.

70058 AN INVESTIGATION OF NUCLEATE BOILING FROM MESH COVERED SURFACES
Naval Postgraduate School, Monterey, Calif., Francis Carl Gregory (M.S. Thesis), Jun. 1970, 64 p., refs. Avail:TAC

A boiler apparatus, designed to simulate heat pipe operation, was built and used to investigate nucleate boiling at atmospheric pressure from mesh covered surfaces using distilled water as the working fluid. The wick materials used included 50 mesh, 80 mesh, and 150 mesh nickel screen; 100 count Lektromesh, a one-piece electrodeposited metallic-sheet material; and 30-40 mesh glass beads. Various wick compositions and water levels were investigated. Vapor bubble migrations within the wick material influenced the performance of the apparatus. Providing a means for vapor escape improved the performance considerably. As a result, performance could be improved by using wick materials having larger mesh openings. Sintering screen samples to the boiler surface to reduce contact resistance did not improve performance.

70059 SURFACE WETTING THROUGH CAPILLARY GROOVES
R. G. Bressler and P. W. Wyatt (Tennessee, University, Knoxville, Tenn.). (American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-19). ASME, Transactions, Series C-Journal of Heat Transfer, vol. 92, Feb. 1970, p. 126-132, 13 refs. Contract No. Nonr-4289(02), Avail:TAC

The effects of capillary grooves on surface wetting and evaporation have been analyzed. An attempt has been made to obtain expressions which approximately describe the increase in heat transfer in order to select for given properties and temperature differences a groove of optimum design. For this purpose, it is assumed that the heat transfer mechanism is determined by thermal resistance of the liquid layers inside the grooves. From a numerical evaluation of linearized equations, heat transfer rates have been computed for grooves with triangular, semicircular, and square cross sections.

70060 IRREVERSIBLE THERMODYNAMIC ANALYSIS OF THE AXIALLY HEATED HEAT PIPE
Adt, R. R., Jr. U. of Miami, Coral Gables, Fla. Proc. 6th Southeastern Seminar on Thermal Sciences, April 1970, Raleigh, N.C. Avail:TAC (16p), 16 refs.

The axially heated heat pipe is analyzed with the inclusion of the irreversible thermodynamic analysis of the phase change process. At low temperature operation an evaporation rate limit is found to limit heat transfer rates and the omission of non-equilibrium effects at the liquid vapor interfaces is shown to result in large errors in temperature distribution predictions.

70061 THE MECHANISM OF HEAT TRANSFER IN THE EVAPORATOR ZONE OF A HEAT PIPE
Ferrel, J. K. and Johnson, H. R., ASME paper, 70-HT/SpT-12, Avail:TAC, 9p.

The results of an experimental investigation of the mechanism of heat transfer during the evaporation of a fluid in a porous wick structure in contact with a heated surface are reported. The experimental configuration was such that the liquid was drawn to the heated surface by capillary action as in a typical heat pipe. Experimental results for both the heat transfer coefficient and the critical heat flux are compared with predicted values based on the mechanism proposed by Ferrell and Alleavitch. The results indicate the mechanism to be substantially correct. The wick materials studied were beds of monel and glass beads.

C.4 FLUID FLOW

50001 INVESTIGATION OF FLOW THROUGH SCREENS
Baines, W. D., Peterson, E. G., Am Soc Mech Engrs--Advance Paper n 50--A-23 for meeting Nov 26-Dec 1 1950, Trans. ASME July 1951, p. 467-80, Avail:TAC

Study of effects of perforated plates and relatively coarse lattices placed perpendicular to fluid flow; effects investigated were dictated by uses made of screens and were divided into three main categories; pressure drop across screen, modification of velocity distribution caused by screen, and turbulence resulting downstream from screen.

62001 RECIRCULATION OF A TWO-PHASE FLUID BY THERMAL AND CAPILLARY PUMPING
J. H. Laub and H. D. McGinness (California Inst. of Tech., Pasadena, Jet Propulsion Lab.). Dec. 8, 1961 (JPL-TR-32-196). Contract NASw-6. 14p.

A closed-cycle gas-supply system for gas bearings and gas-floated devices is described which eliminates mechanical pumps or compressors and uses instead thermal and capillary pumping action. A small quantity of a two-phase fluid of suitable thermodynamic characteristics, such as Freon, is recirculated in a closed system. The fluid is thermally vaporized in an evaporator, and the superheated vapor, after passing through the gas bearing, is condensed and returned to the evaporator by capillary action. The system is of special interest to space applications, because it can operate in a zero-g environment from solar or nuclear power sources, without conversion to electrical energy.

66023 TWO-PHASE MOMENTUM FLUX AND DESIGN OF A HEAT PIPE
Massachusetts Inst. of Tech., Cambridge, Gerry B. Andeen, Fred R. Kern, and Peter Griffith, Progress Report, 30 Jun. 1965, 42 p. (Contract AT(30-1)-3496) (TID-22224), Avail:TAC

The momentum flux in upward two-phase flows through tubes is measured and analyzed, and models are studied. The calculations are presented in forms suitable for determinations of pressure drops in pipe flows. Fluctuations in momentum flux are studied. Excitation of physical oscillations by these fluctuations is discussed. The development of a heat pipe, and the factors governing the performance of such a pipe, are studied. The factor that limits heat transfer in water-filled wick-return heat pipes is found to be conduction through the wick at the cold end. For these heat pipes, it is found that very small amounts of noncondensable gases can cause dramatic reductions in the heat transfer performance of the heat pipe.

66024 EXPERIMENTAL FEASIBILITY STUDY OF WATER-FILLED CAPILLARY-PUMPED HEAT-TRANSFER LOOPS
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Francis J. Stenger, Washington, NASA, Nov. 1966, 34 p., refs., Avail:TAC (NASA-TM-X-1310)

Two capillary-pumped heat-transfer loops were fabricated and tested to study their general characteristics. With water as a working fluid, the loops were operated over a power input range from 248 to 1000 watts in a temperature range from 212° to 291°F. The first loop, with a vapor duct 0.193 inch in inside diameter, was 70 feet long and operated at a maximum power input of 823 watts. The second loop (0.180-in. i.d. vapor duct) was 52 feet long and operated at 700 watts in a variety of orientations with respect to gravity. Although capillary-pumped loops must be designed with care to prevent problems with noncondensable gas, the test results show that such loops can transfer kilowatts of heat over distances greater than 50 feet. The operation of the final test loop was not sensitive to its orientation with respect to gravity.

66025 VISCOUS FLOW IN A RECTANGULAR CHANNEL HEAT PIPE WICK
Mike Janssen, Lawrence Radiation Lab (UCID-15518) Space Power Note 195, Nov. 1966 Avail:TAC (8p), 2 refs.

Analytical investigation of the flow in a channel wick. The pressure gradient required to carry a mass flow rate at some point down the channel is calculated by solving the much simplified Navier-Stokes equation for laminar flow. The friction factor at different channel depth to width ratios and different flow velocities is determined and graphed.

66026 ANNULAR HEAT PIPE THEORY
Watts, J. L., Lawrence Radiation Lab., University of Calif., Livermore. (UCID-15519. November 17, 1966) Avail:TAC (28p), 7 refs.

Using the usual assumptions regarding fluid flow, the Navier-Stokes equation can be solved analytically for the annular type heat pipe. The author carries out the solution in detail and gives an additional first order approximation formula which is not only easy to use but sufficiently accurate for all practical cases.

67041 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
North Carolina State Coll., Raleigh, J. K. Ferrell and A. Carnesale, Quarterly Progress Report, 1 Oct.-31 Dec. 1966, 1 Feb. 1967, 30 p., ref. (Contract AT(40-1)-3411) (TID-23809; QPR-6), Avail:TAC

The operating characteristics of a stainless steel heat pipe are described along with an analytical model for predicting operating limits of capillarity-limited heat pipes. A continued analysis of a transient capillary rise model was performed along with comparisons with experimental data. Analysis of basic capillarity phenomena was continued, including determination of meniscus shapes under various conditions.

67042 PRESSURE DROP IN THE VAPOR PHASE OF LONG HEAT PIPES
Busse, C. A. (Euratom CCR, Ispra (Vanese), Italy) Avail:TAC (11p), 6 refs.

Laminar vapor flow in cylindrical heat-pipes is analyzed assuming that the heat pipe consists of a heating zone, a heat-shielded zone and a cooling zone, that the length of each zone is large compared with the diameter, and that the heating and cooling rates are constant. The vapor flow is described by the Navier-Stokes equation which is simplified for the case of a long heat-pipe and solved by approximating the axial velocity component by a polynomial of the fourth power of the radius. The analysis shows that the profile of the axial velocity component (divided by the average axial velocity) is constant along the heating zone, that it approaches the Poiseuille profile in the heat-shielded zone, and that it varies strongly along the cooling zone deviating already considerably from the Poiseuille profile for radial Reynolds numbers of minus one. Analytical expressions for the axial pressure profile and relations for the integral axial pressure drop are derived for all positive values of the radial Reynolds number (heating zone), and for negative values (cooling zone) down to about minus one.

68030 HEAT TRANSFER IN A TWO-PHASE THERMOSYPHON TUBE
B. S. Larkin (National Research Council, Div. of Mechanical Engineering, Gas Dynamics Laboratory, Ottawa, Canada). Canada, National Research Council, Division of Mechanical Engineering and National Aeronautical Establishment, Quarterly Bulletin, no. 3, 1967, p. 45-53, Avail:TAC

Discussion of a particular form of thermosyphon (a sealed tube partly filled with a working fluid). The condensate is returned from the cooled end to the heated end by gravity. Such a tube has a conductivity that is at least two orders of magnitude higher than that of a solid bar of copper. As the condensate return is by gravity, this high conductivity is effective only when the heat flow is upward. A similar device known as a heat pipe is being developed for use in zero-gravity conditions. The heat pipe differs from the tube discussed in that the condensate is returned to the heated end by means of a wick that is built into the tube. Possible uses of the thermosyphon tube are enumerated and an experimental program is outlined.

69071 THEORETICAL INVESTIGATION OF HEAT PIPES OPERATING AT LOW VAPOR PRESSURES
E. K. Levy (Lehigh University, Mechanical Engineering Dept., Bethlehem, Pa.). (AVIATION AND SPACE: PROGRESS AND PROSPECTS; PROCEEDINGS OF THE ANNUAL AVIATION AND SPACE CONFERENCE, BEVERLY HILLS, CALIF., JUNE 16-19, 1968, p. 671-676.) ASME, Transactions, Series B - Journal of Engineering for Industry, vol. 90, Nov. 1968, p. 547-552, 8 refs., Avail:TAC

Consideration of the heat pipe, a device which can transfer a large quantity of heat with a relatively small temperature drop by the evaporation of a liquid, the transport of the vapor through a duct, and the subsequent condensation of the vapor at the heat-rejection surface. A one-dimensional analysis of a compressible vapor flowing within the evaporator section of a heat pipe is presented. Comparisons between the theoretical results and existing heat-pipe data show that the presence of a gas-dynamic choking can limit the heat-transfer capacity of a heat pipe operating at sufficiently low vapor pressures.

69072 LIQUID-VAPOUR INTERACTION AND EVAPORATION IN HEAT PIPES
A. Baehr, E. Burck, and W. Hufschmidt (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg. EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 543-556, 6 refs., Avail:TAC

Experimental study of liquid-vapor interaction in loop plates with different heat-pipe capillary geometries using water as the liquid in the open capillaries. The decrease of the transported water mass-flow by increasing air velocity was measured, and the results are compared with the analytical solution given by Di Cola (1968). In addition, the processes in the interior of a heat pipe were observed visually. An inverse heat-pipe was constructed with water as the heat transporting medium. It consists of three concentric tubes, an inner stainless steel tube with a capillary system at the outer surface, and two involving glass tubes. The water is in the gap between the steel tube and the inner glass tube. One part of the steel tube is heated electrically, the other is cooled by a water flow. The investigations made with this heat pipe cover: liquid distribution along the capillaries, dry-out of the heated surface caused by bubble formation, asymmetrical liquid distribution, and rewettability of the surface after dry-out.

69073 ULTIMATE HEAT-PIPE PERFORMANCE
Joseph E. Kemme (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.). (Institute of Electrical and Electronics Engineers, Annual Thermionic Conversion Specialist Conference, 7th, Framingham, Mass., Oct. 21-23, 1968.) IEEE Transactions on Electron Devices, vol. ED-16, Aug. 1969, p. 717-723, 10 refs., Avail:TAC
AEC-sponsored research

Ultimate heat-transfer limitations imposed by sonic vapor flow were determined in heat pipes for sodium, potassium, and cesium working fluids. Each fluid was investigated in a heat pipe consisting of an inner porous tube, an annulus for liquid return, and an outer container tube. Thin, rigid tubes with very small pores were obtained by compressing several layers of fine-mesh screen. These tubes allowed large capillary forces to develop so that sonic vapor flow could be achieved at several operating temperatures. The results of the investigation showed that sonic limitations were influenced strongly by the temperature and the working fluid. Reasonable agreement was found between the experimental results and existing theory. It was also found that the theory could be used to predict evaporator pressure and temperature gradients when the heat pipes were operated at various fractions of their ultimate heat-transfer capability.

69074 HEAT PIPE CHANNEL FLOW DISTRIBUTIONS
Lawrence S. Galowin (Singer-General Precision, Inc., Research Center, Fluidics Dept., Little Falls, N.J.) and Vincent A. Barker (Numerisk Institut, Copenhagen, Denmark). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-22, 14 p., 10 refs., Avail:TAC

Solutions for the gas phase, self-induced pressure field and laminar velocity distribution of the working fluid within closed heat pipe channels were obtained by a momentum integral method. The von Karman-Pohlhausen boundary layer integral method was adopted with a two-parameter velocity profile. Wall boundary conditions at the wick simulate the vapor phase emission and return by a porous wall with distributed wall injection and suction along the length. The flow vanishes at the solid ends of the channel while the arbitrary injection and suction wall distributions are related to the surface area heat input and rejection distributions. Approximate closed form solutions of the resulting nonlinear differential equation were obtained for velocity distributions and pressure fields with constant and linearly varying distributions of suction and injection. A computer program for numerical solution was developed for arbitrary functions of wall injection and suction. Convergence and the uniqueness of a solution were investigated by numerical experiments.

69075 EXPERIMENTAL STUDY OF VAPOR VELOCITY LIMIT IN A SODIUM HEAT PIPE
G. S. Dzakowic, F. G. Arcella (Westinghouse Electric Corp., Astronuclear Laboratory, Pittsburgh, Pa.), and Y. S. Tang. American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-21, 8 p., 11 refs., Avail:TAC

For the understanding of heat transfer capability and startup behavior of heat pipes, an experimental study was conducted on the heat transfer limit due to maximum vapor velocity at the end of the evaporator section. Axial temperature profiles on a sodium heat pipe are reported with different rates of heat transport through the pipe. Good correlation is obtained between the measured and predicted heat transfer limits. A constant ratio of static pressures across the evaporator section is deduced from surface temperature measurements to substantiate the occurrence of sonic velocity.

69076 QUARTERLY STATUS REPORT ON THE SPACE ELECTRIC POWER R AND D PROGRAM FOR THE PERIOD ENDING JANUARY 31, 1969. PART I.
Los Alamos Scientific Lab., N. Mex., Feb. 26, 1969. Contract W-7405-eng-36. 9 p., Avail:TAC

Equations used in heat pipe design are presented including an equation to show the effects of vapor density and velocity on heat transfer. Sonic limitations for Cs, K, Li, and Na heat pipe working fluids are given. Compatibility evaluation of the Re-Ag heat pipe at 2000°C was terminated because of a leak in the evaporator section of the pipe. High purity Re when used in a two metal system will operate satisfactorily at 2000°C in excess of 300 hrs without detectable entrainment between the metals. If high purity W is employed in the W-Ag system, the system has the same capability. In the Re-W-Ag system, in which W was used as the wick mass transport of W was found. A new Hg pipe was built, loaded, and tested for 4,600 hr operation at 300°C. A modified variable-spacing diode system test indicated some degree of local thermodynamic equilibrium. Data were insufficient to determine the magnitude of departure from equilibrium. Electron temperatures did not exceed 2800°K despite the high current densities and close spacings.

69077 DETERMINATION OF LOSS OF PRESSURE IN CAPILLARY MEDIA CAPABLE OF BEING USED IN HEAT PIPES
Note TT No. 265. Schmidt, E. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). (NP-18004), Apr. 27, 1967, 41p. (In French), Avail:TAC

The pressure loss in capillaries composed of several layers of a sieve with different meshes and placed horizontally in a square pipe was studied experimentally. The tests were made with water, but the results are valid for other liquids such as sodium. The coefficient of friction, $\underline{f}$, was determined as a function of the Reynolds number (Re < 300) on the basis of the test results.

69078 LIQUID VAPOR INTERACTION IN HEAT PIPES
W. Hufschmidt et al., Wärme- und Stoffübertragung Bd. 2 (1969) S. 222-239 (In German) Avail:TAC (20p)

For heat pipes with a structure of open capillaries in the transport section the vapor flow in the tube influences the laminar liquid flow in the capillaries in contrary direction by the shearing of the vapor at the free liquid surface. The two dimensional Navier-Stokes equation for the liquid flow in the rectangular capillaries has been solved by a Fourier transformation. The evaluation yielded the friction factor of the liquid flow under the influence of the vapor shearing and has been found markedly greater than in case without vapor flow. By this effect the performance of the heat pipe is decreased (e.g. for a Na-heat pipe at 800°C, 1 m length, 20 mm diameter, the reduction will be about 30%). At the liquid surface are zones with considerable return flow in vapor flow direction which are important for corrosion problems. In an experimental facility have been investigated plates with different capillary geometries. In the capillaries flowed water and over the plates air in contrary direction. The decrease of the transported water flow rate with increasing air velocity has been investigated. The measured friction factors of the water flow followed rather well the predicted values. This means that the assumptions for the boundary condition at the liquid surface--locally constant sheer stress and no ripple formation--hold for the solution of the Navier-Stokes equation. If the capillaries in the plates are covered by a layer of a fine mesh no influence of the shearing of the air flow in the waterflow in the grooves has been measured. Up to air velocities of 11.5 m/s (corresponding to an airflow Reynolds number of about 10^5) no entrainment of water droplets from the mesh could be observed.

70062 VAPOR COMPRESSIBILITY EFFECTS IN HEAT PIPES
Lehigh Univ., Bethlehem, Pa., Dept. of Mechanical Engineering, Edward K. Levy and Shyan-Fu Chou, May 1970, 76 p., refs. (Contract AT(30-1)-4095) (NYO-4095-1; PR-1), Avail:TAC

The preliminary results from an analytical study of the effect of vapor dissociation and vapor supersaturation on the sonic velocity limit in sodium heat pipes are presented. For a sodium vapor flow which is in chemical equilibrium but which is frozen with respect to liquid-vapor phase change, computed values for the maximum rate of heat transfer based on the sonic limit and for the axial drop in heat pipe temperature are presented and are shown to be in good agreement with recent experimental results from the literature. A comparison between the chemical equilibrium, reacting, and frozen flow analyses shows small variations in maximum heat transfer rates but large differences in the amounts of vapor supersaturation.

70063 EFFECT OF GRAVITY ON THE HEAT TRANSFER IN HEAT PIPES (SCHWERKRAFTEINFLUSS AUF DEN WÄRMETRANSPORT IN WÄRMEROHREN)
L. Reichle (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Forschungszentrum, Braunschweig, West Germany). (Deutsche Gesellschaft für Luft- und Raumfahrt, Jahrestagung, Bremen, West Germany, Sept. 22-24, 1969, Paper 44.) Raumfahrtforschung, vol. 14, Jan.-Feb. 1970, p. 13-17, 12 refs. In German, Avail:TAC

Discussion of the maximum heat flow in a heat pipe in the presence of gravity effects of varying magnitude and of the effect of gravity on heat transfer during evaporation and condensation processes in a heat pipe. The maximum heat flow in a heat pipe which operates against the force of gravity is calculated, using a simple physical model. The results are discussed, taking into account conditions in a sodium-filled heat pipe at a temperature of 900 deg K. The limits of transferable heat flow are investigated on the basis of the relations governing heat transfer during evaporation and condensation processes with allowance for the effects of gravity.

70064 FLOODING PHENOMENON IN A CRYOGENIC HEAT PIPE WITH VERTICAL COUNTERCURRENT TWO-PHASE FLOW
Ewald, Rolf; Lacaze, Albert; Perroud, Paul (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires), 1970. (CEA-CONF-1496), 14p. (In French). (CONF-700522-1). Avail:TAC. From 3rd International Cryogenic Engineering Conference, West Berlin, Germany.

A vertical tube has been used to study experimentally the behavior of a vaporization-condensation cryogenic heat pipe, by analogy to the well-known heat pipe recently developed for higher temperatures. The flow in the vertical tube connecting the vaporizer to the condenser is countercurrent, the liquid flowing downwards as in annular film at the wall, while the vapor circulates upwards in the center. Experiments have been carried out in a glass apparatus using nitrogen, hydrogen, and deuterium boiling under medium pressures. The thermal power supplied to the boiler cell and the diameter of the vertical tube were varied until flooding occurred. A dimensional analysis permitting a good correlation of experimental results is presented. A comparison of the data with previous correlations established for other fluids at room temperature is also given.

71020 A STUDY OF NONCONDENSABLE EFFECTS IN A HEAT PIPE
Colwell, G. T. et al. Nuclear Technology, Vol. 10, March 1971, p. 293-300. Avail:TAC

Experimental data are presented showing the effects of introducing argon into the vapor space of a water heat pipe under conditions of low to moderate heat-transfer rates. At low heat transfer the presence of argon very greatly affected the thermal conductance of the heat pipe while at higher energy transfer rates the effects of the noncondensables were considerably diminished. Correlation equations are presented which take account of the effects of the presence of various quantities of noncondensable gas on heat-pipe performance.

71021 POSSIBLE APPLICATION OF ELECTRO-OSMOTIC FLOW PUMPING IN HEAT PIPES
Momtaz Abu-Romia, Polytechnic Institute of Brooklyn, Brooklyn, N.Y., AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

This paper proposes a scheme of utilizing electro-osmosis for flow pumping to increase the maximum heat capability of the heat pipe, and pressure generation to overcome the presence of vapor lock in the evaporator section of the pipe. The theory of electrokinetics in connection with heat pipe dynamics is outlined. A model which predicts the relative contribution of electro-osmotic flow pumping on the heat capability of the pipe is presented. Numerical calculations for a supposed heat pipe, operating with different dilute water solutions and utilizing glass beads as a wick material, indicate an increase in the heat pipe capability of several orders of magnitude, depending on the applied electric potential.

71022 EFFECTS OF FRICTION ON THE SONIC VELOCITY LIMIT IN SODIUM HEAT PIPES
E. K. Levy, Lehigh University, Bethlehem, Pa., AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

Analytical results are presented which demonstrate the effect which the wall shear stress acting in the vapor flow passage has on the behavior of a sodium heat pipe operating in the sonic limit regime. It is shown that because of the wall shear stress in the adiabatic region, gasdynamic choking will occur at the exit plane of the adiabatic region rather than at the evaporator exit. At a given value of operating temperature, the shear stress will reduce the maximum rate of heat transfer based on the sonic limit to a value lower than is expected from the frictionless analysis.

D. DESIGN AND FABRICATION

D.1 GENERAL

64003 STATUS REPORT ON HEAT PIPES
R. J. Campana, J. W. Holland. Gulf General Atomic (GA-5676) Sept. 17, 1964. Avail: TAC (43p) 17 refs.

A general description of heat pipes operating as radiating fins is given. A review is made of heat pipe experiments which have been conducted and the literature pertinent to their functional aspects. Subsequently, the six functions of a heat pipe are examined to find the factor which influences heat pipe design and which determines their minimum size and weight.

65014 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING JANUARY 31, 1965
Los Alamos Scientific Lab., Univ. of California, N. Mex., Feb. 1965. Contract W-7405-eng-36. 55p., Avail:TAC

Research and development are reported on LAMPRE, Fast Reactor Core Test Facility, Omega West Reactor Experiment, ultra-high Temperature Reactor Experiment, and MHD applications. Results of studies on Pu compounds are summarized, and efforts devoted to fabrication of a satellite heat transfer pipe are described.

66027 PERFORMANCE STUDIES ON HEAT PIPES
C. A. Busse, R. Caron, F. Geiger (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy), and M. Pötzschke (Metallgesellschaft AG, Frankfurt, West Germany). IN: EUROPEAN NUCLEAR ENERGY AGENCY AND INSTITUTION OF ELECTRICAL ENGINEERS, INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, LONDON, ENGLAND, SEPTEMBER 20-25, 1965. [A66-15532 05-03]. 1965, 12 p., 9 refs., Avail:TAC

Experimental investigation of the possibility of using heat pipes in space thermionic power supplies for carrying heat to emitters and for dissipating waste heat from collectors, provided that systems of sufficient lifetime can be implemented. This application necessitates heat pipes operating in the temperature regions of 1600 to 1800°C (for emitters) and 1000°C (for collectors). Work is being performed on both systems, with emphasis on emitter heat pipes which pose the more difficult problem, and for which an operational temperature of 1600°C has been envisaged. The following four heat pipe development steps are discussed: (1) selection of the working fluid, (2) selection of container material, (3) heat pipe fabrication, and (4) life testing. A table summarizes the status of development as of the middle of July 1965. Six systems have reached the testing or evaluation stages. Comments are made on each of the systems.

67043 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT
Thermo Electron Engineering Corp., Waltham, Mass., Quarterly Report, 1 Oct. 1966-10 Jan. 1967, 10 Jan. 1967, 22 p. Prepared for JPL. (Contracts NAS7-100; JPL-951465) (NASA-CR-83920; TE-4067-76-67; QR-2), Avail:TAC

Progress is reported on the development of a converter which incorporates a heat pipe concept to transfer heat between the collector and the radiator. Four devices are being fabricated and tested to insure a thorough evaluation of each design before proceeding with the next. The first two designs include only the heat pipe, while the latter two are complete converter structures with the heat pipe collector radiator. The efforts during this period were concerned with the fabrication of the first of the two heat pipe models.

67044 CRYOGENIC HEAT PIPE
Air Force Systems Command, Wright-Patterson AFB, Ohio, Air Force Flight Dynamics Lab., William L. Haskin, Final Report, Mar.-Dec. 1966, Jun. 1967, 59 p., refs. Prepared jointly with Ohio State Univ. (AFFDL-TR-66-228), Avail:TAC

A heat pipe is a metal tube containing a two phase fluid to transport heat over several feet by evaporating liquid at the warm end and condensing the vapor at the cold end. An experimental heat pipe was constructed and instrumented to permit measurements of the heat transport in a nitrogen vapor tube wherein the vapor pressure and boundary temperatures could be monitored. No major effort was made to optimize the performance of the tube tested, but various designs and operating parameters were investigated experimentally to determine their effects on the thermal impedance of the tube. Heat loads of up to 130 watts were transferred axially in this 3/4-inch OD, 33-inch-long heat pipe with less than half the total temperature drop required by a copper rod of comparable size. The main temperature drops in the heat pipe are due to heat conduction through the tube wall and the fluid filled wick liner of the evaporator and condenser sections. When the tube surface temperatures were near the critical temperature of nitrogen, vapor film formation caused a large temperature drop.

67045 HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF SPACECRAFT
Samuel Katzoff (NASA, Langley Research Center, Hampton, Va.). American Institute of Aeronautics and Astronautics, Thermophysics Specialist Conference, New Orleans, La., Apr. 17-20, 1967, Paper 67-310. 24 p., 30 refs., Avail:TAC

Review of the basic theory and applicability of devices that transfer heat by evaporation of liquid from heated areas and condensation on cold areas, with continuous return of the condensate back to the heated area by capillary action. Computed examples are presented to indicate possible applications to the solution of difficult thermal-control problems and to illustrate the principles and methods of analysis. Items discussed include the following: (1) wicks and associated capillary structures for optimum transfer of heat and minimum resistance to fluid flow; (2) characteristics and possible applications of multicomponent systems, such as those using a mixture of two liquids having different vapor pressures; (3) thermal scale models; (4) the general problem of testing and validating the devices in the laboratory 1-g environment; (5) design for evaporative cooling (passing the vapors out of the spacecraft) and short-term applications; and (6) applications for cooling of space power plants.

67046 OPTIMIZATION OF A GROOVED HEAT PIPE
Sidney Frank (Martin Marietta Corp., Baltimore, Md.). IN: ADVANCES IN ENERGY CONVERSION ENGINEERING; AMERICAN SOCIETY OF MECHANICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, MIAMI BEACH, FLA., AUGUST 13-17, 1967, PAPERS. [A67-42485 24-03]. New York, American Society of Mechanical Engineers, 1967, p. 833-845, 6 refs., Avail:TAC

The paper is concerned with the transport, or capillary pumping limitation, of heat pipes using microgrooves as the wick or capillary structure. A generalized heat pipe equation is presented and discussed. This equation is then particularized for the case of a tubular heat pipe with a wick consisting of rectangular grooves, operating either horizontally or in gravity-free space, and rearranged to solve for the ratio of the heat transport rate to the cube of the outer radius of the wick. This ratio is optimized with respect to the width and depth of the grooves, and the result is used to determine the wick configuration for a heat pipe of minimum diameter when the length and heat transport rate have been specified for a particular working fluid and temperature.

67047 HEAT PIPE RADIATOR DESIGN
Space Power Note No. 214. Carlson, G. (California Univ., Livermore, Lawrence Radiation Lab.). June 15, 1967. Contract W-7405-eng-48. (UCID-15165). 49p., Avail:TAC

The design of a heat pipe radiator for SPR-6 is presented. A wide range of parameters may be quickly evaluated through the use of the computer code HPRAD4. A "near-optimum" design yields a 46 Mw radiator with a mass of 12,000 kg.

67048 HEAT PIPE OPTIMIZATION
Cheung, H. Lawrence Rad. Lab., U. of Calif., Livermore (UCID-15531) Space Power Note No. 264 (Dec. 19, 1967) Avail:TAC (14p), 7 refs.

In existing analytical procedures for determining the optimum geometry and performance of heat pipes, certain simplifying assumptions have been made. This note assesses the error incurred in these assumptions by comparing the results of the analytical procedure with those of an exact numerical method. The difference in heat pipe performance predicted by the two methods is about 25%.

67049 ADVANCES IN HEAT PIPE DESIGN
Hall, W. B., Kessler, S. W., 20th Annual Power Sources Conference--Proc, U S Army Electronics Laboratories, Fort Monmouth, NJ May 24-26 1966 p 166-9. Avail:TAC

Performance and design of heat pipe static device capable of efficiently transferring large amounts of heat from fossil-fuel flame to heat sink--using lead as working fluid, alumina as flame barrier, and specially constructed seal joining emitter of thermionic converter and flame barrier; heat pipe designed around concept that fossil-fuel fired converter should use evaporator section of heat pipe as flame barrier and its heat sink section as emitter; iron plated D-43 Co alloy band force-fitted onto round hollow alumina refractory pipe used as seal; wick for return of cooling fluid to flame barrier was 150 mesh Mo screen; at 1450 C losses were only 85 w of heat.

68032 AN ANALYTICAL AND EXPERIMENTAL STUDY OF HEAT PIPES
TRW Systems, Redondo Beach, Calif., L. G. Neal, Jan. 1967, 37 p., refs. (TRW-99900-6114-R000; EM-17-5), Avail:TAC

An analysis of the heat pipe is conducted which results in some design equations and gives a criterion by which working fluids and capillary materials may be chosen. Several heat pipe fluids are evaluated and the best fluids for various temperature ranges are chosen. The experimental effect investigated factors which determine good capillary structures. Three types of capillary materials were used in heat pipe operation. Two heat pipe designs were built and operated to determine their capacities and the mechanism by which they fail. One pipe was frozen and subjected to a startup test at a low power level to investigate the possibility of bringing a heat pipe back to life. The heat pipes were operated using both water and ethyl alcohol as working fluids.

68033 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT
Thermo Electron Engineering Corp., Waltham, Mass., Quarterly Report, 18 Jun.-12 Oct. 1967, 12 Oct. 1967, 13 p. Prepared for JPL. (Contracts NAS7-100;JPL-951465) (NASA-CR-91437; TE-4067-44-68), Avail:TAC

Engineering design data are presented for an experimental heat pipe collector radiator structure. Although similar to three previous models, the heat pipe diameter was enlarged by using a custom made niobium tube to match the ceramic seal size and a larger radiator are of 38.3 cm^2 was developed. Engineering drawings and specific fabrication techniques are included and equations are given for predicting the radiator temperature for any values of output current.

68034 SPACE ELECTRIC POWER R AND D PROGRAM. PART 1
Los Alamos Scientific Lab., N. Mex., Quarterly Status Report, Period Ending 31 Jan. 1968, 21 Feb. 1968, 7 p., refs. (Contract W-7405-ENG-36) (LA-3881-MS, Pt 1), Avail: TAC

Experiments which are being conducted to determine the effect of many variables on the performance of heat pipes are described. These variables include the heat pipe design, the materials used, vapor flow conditions, vibration, type of heat pipe fluid, and the wick design and material.

68035 ENGINEERING DESIGN OF THE HEAT PIPE
North Carolina State Coll., Raleigh, John Howard Cosgrove (Ph.D. Thesis), 1967, 99 p., Avail:TAC

Mechanisms involved in the operation of a self-contained heat transfer device, the heat pipe. A typical configuration for this device is a long closed pipe having its inner wall lined with a liquid saturated wick. One end is heated and the other cooled. The liquid in the wick at the heated end vaporizes, flows to the cool end where it condenses, and then is returned to the heated end by capillary action. Two experimental heat pipes were constructed and instrumented so that their operating characteristics could be accurately and precisely defined at all levels. An analytical study was also made based on the assumption that capillary circulation was the controlling factor in heat pipe operation. The analytical model was based on fundamental mass, heat, and momentum balances in the wick. It related the maximum heat input to the fluid and wick characteristics and to the indiclindation of the pipe with respect to gravity. The model indicated that the critical parameters and operating characteristics were the capillary forces in the wick, pressure drop through the wick, and the operating temperature of the heat pipe. The developed model can be used to determine the operating limits of a capillary controlled heat pipe.

68036 A CONTINUOUS HEAT PIPE FOR SPACECRAFT THERMAL CONTROL
E. C. Conway and M. J. Kelley (General Electric Co., Philadelphia, Pa.). IN: AVIATION AND SPACE: PROGRESS AND PROSPECTS; PROCEEDINGS OF THE ANNUAL AVIATION AND SPACE CONFERENCE, BEVERLY HILLS, CALIF., JUNE 16-19, 1968. [A68-33401 16-34]. New York, American Society of Mechanical Engineers, 1968, p. 655-658, Avail:TAC

The paper presents data which confirm the feasibility of operating a continuous, circular heat pipe having many combinations of evaporator and condenser surfaces. The design and fabrication of such a heat pipe built in the form of a toroid having eight heat sources and eight heat sinks suitable for use in a spacecraft are discussed. Test data are presented showing temperature distributions with several different combinations of heat sources and heat sinks. A brief analysis is included to extend test data for prediction of performance under zero-g conditions.

68037 HEAT PIPE DESIGN MANUAL
Frank, S.; Smith, J. T.; Taylor, K. M. (Martin-Marietta Corp., Baltimore, Md.), Feb. 1967. (MND-3288), 126p.

Results of a program for compiling materials properties in a form useful to heat pipe designers are presented. For each potential heat pipe working fluid considered the properties presented in both engineering and scientific units as a function of temperature are vapor pressure, surface tension, density of liquid, density of vapor, viscosity of liquid, viscosity of vapor, thermal conductivity of liquid, and latent heat of vaporization. Useful groups of parameters presented are liquid transport factor, vapor transport factor, ratio of kinematic viscosities, and wicking height factor.

Where possible, the pertinent properties of water, sodium, cesium, and ammonia have been plotted over the entire range of temperatures from melting point to critical point. In those instances where authoritative data could not be found for certain properties over the useful range (presumably from about 0.1 to 10 atm. of vapor pressure) estimation by calculation and/or extrapolation was used and is so indicated. Melting, boiling and critical temperatures have been indicated on the individual graphs for convenient reference.

68038 WORKSHOP ON HEAT PIPE DESIGN AND ANALYSIS
Feldman, K. T., U. of New Mexico. April 19 and 20, 1968 Avail:TAC (49p), 56 refs.

The heat pipe is a unique high-flux heat-transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to give it an effective thermal conductivity several thousand times that of copper. The major operating characteristics of a heat pipe are: (a) nearly perfect isothermal operation over lengths of several feet, (b) thermal transformer operation where heat is added over a small area at high flux and removed over a large area at a low flux and vice versa, and (c) thermal power flattening where large variations in input heat flux causes very little variation in output heat flux. The heat pipe is ideally suited for energy supply, removal and thermal control of energy conversion systems. Analysis of theoretical heat pipe performance gives the following equation for maximum heat transport rate:

$$Q_{max} = \frac{(\rho\sigma fg)}{\mu} \frac{(KA)}{L'} \frac{(\rho g)}{g_c\sigma}[\ell m - L \cos\phi]$$

Heat pipes have been designed and applied to many thermal systems which are illustrated and discussed.

69079 THEORETICAL AND EXPERIMENTAL DETERMINATION OF THE LIMITING HEAT POWER TRANSPORTED BY SODIUM HEAT PIPES [DETERMINATION THEORIQUE ET EXPERIMENTALE DE LA PUISSANCE THERMIQUE LIMITE TRANSFEREE PAR DES CALODUCS A SODIUM]
E. Schmidt and R. Semeria (Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Grenoble, Service Transferts Thermiques, Grenoble, France). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 515-527. 6 refs. In French, Avail:TAC. Research supported by the Direction des Recherches et Moyens d'Essais

Determination of the limiting heat power transported by sodium heat pipes, using both an analytical model and experimental results. The limiting heat power varies with the geometry of the capillary network, the dimensions of the heat pipe, the angle of inclination in relation to the horizontal, and the temperature of operation. Major attention is given to the capillary network, which consists of several coils of a metallic screen made of square mesh. In several heat pipes of the same geometry, the spacing of the mesh was varied between 0.055 x 0.055 mm and 0.36 x 0.36 mm. The optimum value for heat pipes working against gravity was found to be 0.21 x 0.21 mm. The optimum operation temperature ranged between 600 and 750°C, depending on the inclination of the heat pipe. For the finest screens, the pressure loss due to the flow of the liquid in the capillary network became too high; for coarser screens operating against gravity, the capillary rise was insufficient. Priming tests were conducted with a calcium heat pipe.

69080 HEAT PIPE DESIGN THEORY
E. van Andel (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 529-542, 6 refs., Avail:TAC

Dimensionless approach to the calculation of maximum heat flow in heat pipes and optimization of the capillary structure. Parameters of twelve liquid metals at a temperature range of 600 to 2200 K are given and used in these calculations. Nomograms for direct evaluation of heat-pipe performance and optimum capillary dimension are presented.

69081 THE ROTATING HEAT PIPE--A WICKLESS, HOLLOW SHAFT FOR TRANSFERRING HIGH HEAT FLUXES
Vernon H. Gray (NASA, Lewis Research Center, Applied Heat Transfer Branch, Cleveland, Ohio). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper

69-HT-19, 6 p., 5 refs., Avail:TAC

Description of a new type of heat pipe that rotates about its longitudinal centerline and utilizes centrifugal acceleration instead of capillaries for return-pumping of condensate. Several alternative design configurations are presented. Advantages cited include the ability to overcome effects of gravity and vehicular accelerations, and heat fluxes up to an order of magnitude higher than comparable capillary-type heat pipes. Research tests and analyses on various component parts of the rotating heat pipe are reviewed. Specifically, these tests include the effects of centrifugal accelerations in a rotating boiler, the condensation of vapors on rotating surfaces, the behavior of high velocity vapor in tubes, and the pumping of liquids by rotation of their containers. Finally, the overall performances of the rotating and conventional heat pipes are compared. Three of the many attractive applications of rotating heat pipes are illustrated and described. These examples involve cooling of motor rotors, cooling of jet engine turbine rotor blades, and air conditioning with a compact unit having one moving part.

69082 HEAT PIPES
Fiebelmann, Peter (to EURATOM). U.S. Patent 3,414,475. Dec. 3, 1968. Priority date May 20, 1965, Germany.

A tubular heat pipe comprising an evaporization zone, with an internally mounted fissile heat source, and a condensation zone, with external secondary cooling means is described. The pipe is at least partially filled with a liquid coolant which evaporates in the evaporization zone and returns, after condensing, along the inner surface of the pipe walls to the evaporization zone. A circular gap is formed between the tube wall and the heat source with a capillary inlet.

69083 SOLAR THERMIONIC GENERATOR DEVELOPMENT
Thermo Electron Engineering Corp., Waltham, Mass., Quarterly Report, March 1-May 31, 1968. Contracts NAS7-100; JPL-951263. 32p. (NASA-CR-95980; TE-4055-176-68; QR-10), Avail:TAC. For Jet Propulsion Lab., Pasadena, Calif.

The fabrication and test of converter T-209 were completed. This model was the second to incorporate a collector-radiator heat pipe structure. The heat pipe design was changed substantially in order to remedy a choked heat pipe vapor flow condition observed in the previous model T-208, and subsequent tests showed that this objective was reached. Converter T-209 equalled the highest output observed from any of the rhenium-emitter and rhenium-collector converters fabricated; however, during tests at high heat inputs, the output was found to deteriorate. This was the first instance of degradation experienced, and it appears that it was caused by a leak of sodium vapor from the heat pipe into the converter envelope, which resulted in an increase of the collector work function of 0.17 eV. The mechanism responsible for the sodium leak is not known. The layout of the 16-converter generator was completed, and the design is now ready for the preparation of detailed drawings.

69084 HEAT PIPE DESIGN CONSIDERATIONS
Joseph E. Kemme, Los Alamos Scientific Lab. (LA-4221-MS) Avail:TAC (8p) 16 refs.

Discussion of the principles of heat pipe operation and how these principles can be applied to improve their heat-transfer performance. Included is a description of the manner of operation and a discussion of the effects of various heat-transfer limitations on the capability of a heat pipe. Limitations discussed are sonic, entrainment, wicking and boiling limitations.

69085 A HEAT PIPE OPTIMIZATION CODE, LAM2
Watts, J. L. Lawrence Rad. Lab., U. of Calif., Livermore (UCID-15462) Avail:TAC (14p) 2 refs.

In the evaluation of heat-pipe performance, it is necessary to know the maximum axial heat flux obtainable with respect to the optimum capillary pore size. The LAM2 code was written to calculate this optimum pore size, r_{opt}, and the corresponding maximum axial heat flux, λ_{max}. A FORTRAN listing of the code and the results for a sample problem are presented.

70065 MADCAP, PHASE 2
Fairchild Hiller Corp., Germantown, Md., Space and Electronics Systems Div., Final Report, Jun. 1969, 47 p. (Contract NAS5-9471) (NASA-CR-109252; Rept-632-FR-090-007) Avail:TAC

An experimental effort to establish the feasibility of heat pipe joints and determine the working fluid and groove parameters for various ranges of heat transport capability was completed. The program, which was supported by analysis, substantiated the specifications for the design of a network of heat pipes applicable to the thermal control of MADCAP antenna. The primary objective of the experimental program was to provide a comparison in the performance of four-way joint heat pipes with equivalent straight pipes. The major conclusions are: (1) Four-way joint heat pipes incorporating a screen cross at the miter joint achieve comparable performance to equivalent straight heat pipes. (2) The heat transport rates and temperature gradients along four-way joints are of the order required on MADCAP heat pipe network system. (3) Freon-11 is a satisfactory working fluid. (4) Good correlation exist between analysis and test results. A heat pipe exhibits a very high heat transport capability while maintaining near isothermal conditions along its length. Its use on MADCAP antenna will radically reduce potential thermal gradients and associated distortions.

70066 THE SPACE ELECTRIC POWER R AND D PROGRAM, PART 1
Los Alamos Scientific Lab., N. Mex., Quarterly Status Report, Period Ending 31 Jan. 1970, 20 Feb. 1970, 5 p., refs. (Contract W-7405-eng-36) (LA-4374), Avail:TAC

Results of investigations directed toward a better understanding of heat pipe operational principles are presented. Progress toward the design of a mercury space radiator having a heat-rejection capability that is temperature-dependent is reported. Tests are in progress on heat pipes with wicks consisting of layered woven wire screen. Results of calculations on heat transfer limitations imposed by sonic vapor flow, liquid entrainment, wicking ability, and boiling in the wick are presented for each wick. In other work, treatment of stainless steel pipes to prevent internal hydrogen buildup is reported.

70067 OPTIMUM CRYOGENIC HEAT-PIPE DESIGN
Joy, P. RCA, Camden, N.J. (ASME 70-HT/SpT-7. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (8p), 2 refs.

Of the four common limitations in heat-pipe design (sonic, entrainment, wicking, boiling), the wicking and boiling limits are more frequently encountered in cryogenic heat pipes; but the high vapor velocities leading to sonic and entrainment limitations in high-temperature heat pipes are not ordinarily present in cryo-pipes, which are generally not started up from a frozen condition and do not handle the large heat flux of their higher temperature counterparts. At cryogenic temperatures, the low working-fluid figure of merit results in low-capacity heat pipes extremely sensitive to gravity fields. Gravitational effects must be considered in cryogenic heat-pipe design because of possible applications on spin-stabilized spacecraft and the requirements for testing on the ground, where a 1-g field would exist across the diameter of a horizontal heat pipe. Since it is of utmost importance to determine capillary-pore radius and wick-thickness ratio that will yield the maximum heat pumping for a heat pipe operating in a particular gravity field, equations for optimum pore size, optimum wick-thickness ratio, and maximum heat pumping are derived. The equations are applied to oxygen and nitrogen heat pipes operating at temperatures from 77 to 90K in several gravitational fields. Relationships established for the maximum heat pumping and wick-thickness ratio as a function of heat pipe ID enable the designer to rapidly examine a number of configurations, all of which will transfer the maximum amount of heat the greatest distance for a given fluid and gravity field.

70068 ANALYSIS AND DESIGN OF HEAT PIPES
Feldman, K. T. Univ. of New Mexico (Engineering 868.4, Continuing Education in Engineering and Science. UCLA. Short Course June 22-26, 1970) Avail:TAC (83p), 36 refs.

The heat pipe is a unique high-flux heat-transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to give it an effective thermal conductance many times that of copper. The major operating characteristics of a heat pipe are: (a) near isothermal operation over lengths of several feet, (b) thermal transformer operation where heat is added over a small area at high flux and removed over a large area at low flux or vice versa, (c) thermal power flattening where large variations in input heat flux causes very little variation in output heat flux, and (d) temperature control where a constant temperature may be maintained for large variations in heat transfer rate along the heat pipe. A simplified theoretical analysis of heat pipe performance is presented. Design data for water heat pipes is also presented. Using the theoretical performance equations and the design data, a heat pipe may be designed to satisfy given heat transfer specifications. The heat pipe is ideally suited for energy supply, removal, and thermal control of a wide variety of heat transfer and energy conversion systems. Numerous different heat pipe applications are illustrated and discussed. Finally, a list of suggested experiments, demonstrations and design projects is included.

70069 ORBITING ASTRONOMICAL OBSERVATORY HEAT PIPES - DESIGN, ANALYSIS, AND TESTING
Bilenas, J. A., Harwell, W. Grumman Aerospace Corp., Bethpage, N.Y. (ASME 70-HT/SpT-9 Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (9p), 18 refs.

This paper describes a program of developing and building a set of heat pipes for the Number 3 OAO Spacecraft to be launched in 1970. The heat pipes are incorporated into the spacecraft to minimize its structure temperature gradients and to validate a general approach to the thermal control of large structures. The design and its verification (analytical and experimental) data presented include the studies of interface heat transfer, heat pipe dryout, leak, vibration, chemical compatibility, and spacecraft response.

70071 THEORETICAL ANALYSES OF CRYOGENIC HEAT PIPES
Chi, S. W. Catholic Univ. of America, Washington, D.C. Cygnarowicz, T. A. NASA Goddard Space Flight Center, Greenbelt, Md. (ASME 70-HT/SpT-6. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (9p), 18 refs.

A qualitative investigation of performance of heat pipes using different working fluids is first made; significance of liquid property variations on the performance of the cryogenic heat pipe is observed. Then, a theory for the cryogenic heat pipe, which takes into account the liquid property variations, is developed. Predictions by the present theory compare favorably with Haskin's experiments. A new procedure for design and performance calculations is also developed. The procedure, simple and quick to use, involves the use of the cryogenic heat pipe theory to generate design and performance charts. Examples using the design and performance charts are presented.

71023 CIRCUMFERENTIAL HEAT PIPE SYSTEMS FOR LARGE STRUCTURES
TRW Systems Group, Houston, Tex., O. W. Clausen, B. D. Marcus, W. E. Piske, and R. C. Turner, Final Report, Dec. 1970, 177 p. (Contract NAS9-10299) (NASA-CR-114783), Avail: TAC

A program is described for the design and fabrication of two full scale 50-foot circumferential heat pipes (one water and one ammonia) for test with the subsystems test bed in the NASA/MSC chamber A thermal vacuum test facility. Conventional heat pipe technology was applied to the problems of large scale systems, and manufacturing techniques (e.g., modularization) were developed to permit their fabrication. Thermal vacuum testing was directed toward an investigation of steady-state and transient response characteristics, and to explore potential problems associated with diffusion freezout and start-up.

71024 STUDY TO EVALUATE THE FEASIBILITY OF A FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPE
Dyna-Therm Corp., Cockeysville, Md., Patrick J. Brennan, Sep. 1970, 69 p., refs. (Contract NAS2-5722) (NASA-CR-73475; DTM-70-4), Avail:TAC

Preliminary designs have been completed for both active and passive feedback controlled variable conductance heat pipe systems. In general, an active system appears to have greater design flexibility while at the same time giving sharper temperature control than an equivalent passive system.

71025 DEVELOPMENT OF CRYOGENIC HEAT PIPES
Philip E. Eggers and Aleck W. Serkiz (Battelle Columbus Laboratories, Columbus, Ohio). American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 29-Dec. 3, 1970, Paper 70-WA/Ener-1, 8 p., 10 refs., Avail:TAC

The operation of a LN2 cryogenic heat pipe has been demonstrated experimentally in the range from 78 to 90 deg K. This heat pipe involves a totally new wick concept, viz., the 'parallel capillary channel' wick, which affords a heat flux capability an order of magnitude higher than possible with the more conventional heat pipe wick structures. The experimental measurements were performed utilizing specially designed cryogenic heat pipe evaluation equipment which permitted heat flux measurements accurate to within 8 percent. The design and optimization of the cryogenic heat pipe is discussed including a description of the BCL generalized heat pipe computer program. A comparison of experimental data with analytical predictions is also provided.

71026 DESIGN AND PERFORMANCE OF NONCONDENSABLE GAS CONTROLLABLE HEAT PIPES
J. D. Hinderman and E. D. Waters, and R. V. Kaser, AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

In this paper, a sequence of design steps and guidelines are described which will facilitate the design of noncondensable gas (NCG) controllable heat pipe systems. Working fluid selection, sizing of NCG reservoir, use of a wick in the reservoir, and interaction of the heat pipe with the surroundings are among the factors considered. The performance of several operational NCG heat pipes is described and the controllability is compared with theoretical predictions. Agreement is generally good. In particular, the presence of a wick in the reservoir is shown to increase the sensitivity of the temperature controllability to reservoir temperature variations.

71027 FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPES
W. B. Bienert and P. J. Brennan, Dynatherm Corp., Cockeysville, Md., and J. P. Kirkpatrick, NASA Ames Research Center, Moffett Field, Calif., AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

71028 THE DESIGN, FABRICATION, AND TESTING OF A VARIABLE CONDUCTANCE HEAT PIPE FOR EQUIPMENT THERMAL CONTROL
F. Edelstein and R. J. Hembach, Grumman Aerospace Corp., Bethpage, N.Y., AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

A variable conductance inert gas type heat pipe has been built to provide fine temperature control for spacecraft equipment. The pipe consists of a self-filling artery with a grooved wall capillary system that provides low evaporator to condenser temperature drops. Storage of the inert gas in low temperature reservoir which communicates with the working fluid through the condenser eliminates the usual start-up problems with these devices. Fabrication of the pipe emphasizes the importance of adequate cleanliness procedures. Latest test results are presented.

D.2 WICKS

66028 VAPOR-CHAMBER FIN STUDIES
L. Langston and H. R. Kunz, Pratt and Whitney Aircraft, East Hardford, Conn., First Quarterly Report, May 28-Aug. 28, 1965, Sep. 1965, 85 p., refs. (Contract NAS3-7622) (NASA-CR-54882; PWA-2698), Avail:TAC

This report describes an experimental and theoretical program formulated for obtaining an understanding of the operation of vapor-chamber fins. Results of this program should enable the application of this device to various proposed uses. A mechanistic model and a simplified analysis of fin operation are derived. This model indicates that experimental data is necessary on the permeability, capillary rise, and boiling in fin wicks before an understanding of fin operation can be obtained. Experiments are therefore defined to obtain these quantities. Permeability will be determined by measuring the pressure drop as a function of liquid flow rate through wick specimens. Capillary rise will be determined by measuring the maximum static height that a liquid will rise in a wick. Boiling tests will determine the maximum heat flux density that can be added to liquid-filled wicks before film-boiling occurs. Descriptions of the experimental apparatus to be used in each of these tests are presented. The manner in which the results from these tests will be used to define fin operating characteristics is indicated.

66029 VAPOR-CHAMBER FIN STUDIES
L. S. Langston, A. Sherman, and B. H. Hilton, Pratt and Whitney Aircraft, East Hartford Conn., Second Quarterly Report, Sep. 1-Nov. 30, 1965, Jan. 1966, 57 p., refs. (Contract NAS3-7622) (NASA-CR-54922; DWA-2773), Avail:TAC

Progress is reported in studies to define the mechanism of heat transport in the vapor chamber fin concept for space radiators. Wicking and boiling studies of porous materials, applicable to fins, were conducted. Data from tests in the wicking rise apparatus showed that a relatively long time is required for a liquid front in a sample to reach equilibrium height. The construction of the wick permeability apparatus is described, and preliminary data indicates that the wick friction factor was independent of time. This result implied that dissolved gas was the cause of the time dependent wick friction factor previously reported. A description of the wick apparatus is also included. Preliminary tests were run using a flat plate sample, and a discussion of the results is provided.

66030 VAPOR-CHAMBER FIN STUDIES
L. S. Langston, A. Sherman, and B. H. Hilton, Pratt and Whitney Aircraft, East Hartford, Conn., Third Quarterly Report, 1 Dec. 1965-28 Feb. 1966, Apr. 1966, 131 p., refs. (Contract NAS3-7622) (NASA-CR-54989; PNA-2818), Avail:TAC

Wicking ability, permeability, and boiling characteristics of various porous meta-lic materials were evaluated, and vapor-chamber fins using materials found to have the most promising capillary properties were tested. Porosity, pore size distribution, and free-flow area ratio of porous metal samples were determined. Wicking rise tests were conducted using water and Freon 113. The equilibrium height of the water front was found to vary from 2.10 in. in a sintered screen sample to 21.0 in. in a sintered powder sample. Equilibrium heights with Freon 113 were lower, due primarily to its lower surface tension. The wick friction factor was measured in permeability tests utilizing water. This factor was found to be independent of flow rate for low flow rates, and independent of liquid temperature. The boiling heat transfer characteristics of a flat plate, two sintered screen samples, and a sintered powder sample were measured. All the porous samples had lower heat transfer coefficients than the flat plate. This was attributed to the premature occurrence of film boiling, caused by the entrapment of vapor bubbles in the wick matrix.

67050 HEAT PIPE CAPABILITY EXPERIMENTS
Los Alamos Scientific Lab., N. Mex., J. E. Kemme, 27 Oct. 1966, 42 p., refs. (Contract W-7405-ENG-36) (LA-3585-MS), Avail:TAC

Axial heat transfer limits were determined for several heat pipe systems having the same outside dimensions, but different wick configurations. Measurements were made at temperatures from 450 to 850°C by using potassium and sodium as working fluids. The wicks consisted of many axial channels, evenly spaced around the inside circumference of each container tube. Different size channels were studied and, in some tests, a layer of fine screen was used to cover the channels and separate them from the vapor passage. The experiments were chosen to show some possible methods for wick improvement and to check the validity of existing heat pipe equations. At higher test temperatures, good agreement was obtained between measured and calculated heat transfer limits. At low temperatures, however, heat transfer capability was below that predicted by theory, and startup difficulties were encountered with the open-channel systems. These problems appear due to an interaction between low-density, high-velocity vapor and returning liquid. The screen covering helped startup and substantially increased heat transfer capability at all operating temperatures.

67051 RESEARCH STUDY ON INSTRUMENT UNIT THERMAL CONDITIONING HEAT SINK CONCEPTS
AiResearch Mfg. Co., Los Angeles, Calif., D. W. Graumann, Quarterly Progress Report, Jun. 1-Aug. 31, 1966, 9 Sep. 1966, 24 p., ref. (Contract NAS8-11291) (NASA-CR-82794; Rept. 66-1174; QPR-2), Avail:TAC

Progress is reported in the development of two modules. Research on a water boiler heat sink module included testing of wick heat transfer, wick performance, and wicking height. Metal and nonmetal wicks were tested. A breakthrough analysis was performed on a water sublimator heat sink module, and capillary tubes were tested to verify analytical predictions. The effects of pore exit sharpness and contact angle on breakthrough pressure were determined. Porous plates were bench tested, and tabulated test results are presented for several specimens.

67052 HEAT PIPE CAPABILITY EXPERIMENTS
Los Alamos Scientific Lab., N. Mex., J. E. Kemme. In: Sandia Corp. Proc. of Joint AEC/Sandia Lab. Heat Pipe Conf., Vol. I, Oct. 1966, p. 11-25, refs. (See N67-26791 14-33), Avail:TAC

Axial heat transfer limits were determined as a function of temperature for some 3/4-inch OD x 12-inch long heat pipes. This information was obtained at temperatures from 450 to 850°C by using K and Na as working fluids. The wicks consisted of many axial channels cut into the inner wall of each tube. The vapor passage diameter was essentially 1.5 cm for all tests, but sizes of the capillary channels were varied both in width and depth. In some cases, one layer of fine screen was used to cover the channels and separate them from the vapor passage. Heat transfer limits were measured from 200 watts to 4000 watts as dictated by the heat removal system. Results obtained within this range show the effect of temperature, working fluid, channel size, and the use of screen. Startup problems and lower heat transfer rates than those predicted by theory were encountered at low temperatures. These problems appear due to an interaction between low density, high velocity vapor, and returning liquid. A layer of screen covering the liquid capillary return system helps startup and substantially increases the maximum heat transfer rate of a heat pipe throughout its useful temperature range.

67053 VAPOR CHAMBER FIN STUDIES. TRANSPORT PROPERTIES AND BOILING CHARACTERISTICS OF WICKS
H. R. Kunz, L. S. Langston, B. H. Hilton, S. S. Wyde, and G. H. Nashick, Pratt and Whitney Aircraft, East Hartford, Conn., Washington, NASA, Jun. 1967, 188 p., refs. (Contract NAS3-7622) (NASA-CR-812; PWA-2953), Avail:TAC

Wicking material properties for the operation of a vapor-chamber fin or a heat pipe are considered. Materials studied are sintered metal screens, sintered metal powders, and sintered metal fibers, with porosities of 47.7 to 91.8%. The results of wick equilibrium height experiments and wick permeability experiments run on the three classes of wicking materials are presented. Both water and Freon 113 are used as working fluids in these experiments. These results are combined to yield the capillary pumping characteristics of wicking materials. Comparison of results with the heat transfer characteristics of a flat plate submerged in water indicate that equivalent or superior performance can be obtained with wick covered surfaces. However, the data also indicate that the entrapment of vapor bubbles in the wick matrix may cause premature film boiling in the porous material at relatively low heat fluxes, depending on the structure of the wicking material. The heat transfer characteristics of Freon 113 were poorer than those exhibited by water.

67054 RESEARCH STUDY ON INSTRUMENT UNIT THERMAL CONDITIONING HEAT SINK CONCEPTS
Garrett Corp., Los Angeles, Calif. AiResearch Manufacturing Div., Quarterly Progress Report, 1 Sep.-30 Nov. 1966, D. W. Graumann, 19 Dec. 1966, 52 p. (Contract NAS8-11291) (NASA-CR-89618; Rept. 66-1491), Avail:TAC

Wick boiler modules were tested to determine the relative performance of rectangular and triangular fins. A test module was designed and fabricated, and testing continued. Vertical and horizontal wicking rate tests were performed. Bench tests were performed on porous plates and a pressure drop correlation was developed. Single module sublimator tests were conducted to determine the performance of various porous plates. Preliminary panel designs were conceived and initial analyses begun.

67055 EXPERIMENTELLE UNTERSUCHUNGEN AN NATRIUM-GEFUELLTEN HEAT PIPES (EXPERIMENTAL INVESTIGATIONS ON SODIUM-FILLED HEAT PIPES) (KFK-512)
Dorner, S.; Reiss, F.; Schretzmann, K. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Neutronenphysik und Reaktortechnik). Jan. 1967. 21p. (In German). Avail:TAC

The possibilities of producing heat pipes and, especially, the necessary capillary structures are discussed. Several types of heat pipes are made from stainless steel and tested at temperatures between 400 and 1055°C. The thermal power was determined by a calorimeter. Bubble-free evaporation of sodium from rectangular open channels is possible with a heat flux of more than 1,940 W/cm^2 at 1055°C. The temperature drop along the tube could be measured only at low temperatures. A subdivided heat pipe worked against the gravitational field. A heat pipe with a capillary structure made of a rolled screen supported by rings and bars operated at 250 W/cm^2 heat flux in the evaporating region.

68039 DETERMINING WICKING PROPERTIES OF COMPRESSIBLE MATERIALS FOR HEAT PIPE APPLICATIONS
R. A. Farran and K. E. Starner (Aerospace Corp., El Segundo, Calif.). IN: AVIATION AND SPACE: PROGRESS AND PROSPECTS; PROCEEDINGS OF THE ANNUAL AVIATION AND SPACE CONFERENCE, BEVERLY HILLS, CALIF., JUNE 16-19, 1968. [A68-33401 16-34] New York, American Society of Mechanical Engineers, 1968, p. 659-670. 13 refs. Contract No. AF 04(695)-67-C-0518, Avail:TAC

Results of an experimental program to develop techniques for determining the wicking characteristics of nonrigid materials for potential use in heat pipes. The principal quantities of interest are effective pore size and permeability. Experiments were conducted with woven Refrasil sleeving to determine the wicking characteristics. The apparent permeability of the Refrasil increased with increasing height, while effective pore size decreased, except at relatively low heights, where these two quantities remained constant. It was concluded that the conventional maximum static pumping head provides little information useful in predicting the wicking capability of some fabric materials. It was also concluded that wicking properties of compressible materials can best be determined by conducting wicking rise tests and by verifying the results of such tests with evaporation tests.

68040 HIGH-PERFORMANCE HEAT PIPES
Kemme, Joseph E. (Los Alamos Scientific Lab., N. Mex.). [1967]. Contract W-7405-eng-36. 4p. (LA-DC-9027) (CONF-671045-4). Avail:TAC. From IEEE Thermionic Conversion Specialist Conference, Palo Alto, Calif.

The heat transfer capability of a heat pipe depends to a large extent on the wick structure. Composite wicks are being investigated in heat pipes having several axial channels covered with screen. High heat transfer rates have been obtained with a very fine screen cover and relatively large channels. The fine screen cover provides a large capillary force for fluid circulation. It also suppresses liquid entrainment which might otherwise limit heat transfer. The protected channels provide a low impedance path for liquid return. It is shown that all of these wick functions are important and need to be considered in the design of high performance heat pipes.

69086 DETERMINATION OF WICKING PROPERTIES OF COMPRESSIBLE MATERIALS FOR HEAT PIPE APPLICATIONS, MARCH 1967-MARCH 1968
Aerospace Corp., El Segundo, Calif., Lab. Operations, R. A. Farran and K. E. Starner, Jul. 1968, 51 p., refs. (Contract F04701-68-C-0200) (AD-679975; TR-0200(4240-10)-7; SAMSO-TR-68-428), Avail:TAC

An experimental program was conducted to develop techniques for determining the wicking characteristics of nonrigid materials for potential use in heat pipes. The principal quantities of interest are effective pore size (to calculate a driving potential for capillary pumping of liquids) and permeability (to establish resistance to liquid flow). Compressible wicking materials do not readily lend themselves to some of the more conventional procedures used for determining flow properties as, e.g., in measuring permeability by forcing a liquid through a rigid, porous material after which flow rate and pressure drop measurements are used to calculat permeability. Consequently, other methods were investigated. Experiments were conducted with woven sleeving to determine the wicking characteristics mentioned above. Results of these tests are presented and compared with performance predicted from theory.

69087 EXPERIMENTAL DETERMINATION OF WICK PROPERTIES FOR HEAT PIPE APPLICATIONS
R. A. Freggens (Radio Corporation of America, Lancaster, Pa.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03). Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 888-897, Avail:TAC

The design of practical heat pipes requires exact knowledge of wick properties. Two of the most important wick properties are the "effective" pumping pore size and the permeability. A series of measurements was made to determine these values for three classes of wick materials. By expressing the velocity of fluid rise vs height of rise against gravity, an equation is presented which relates wick pumping ability to power dissipation for reentrant heat pipe designs. A further heat pipe wick limitation, that of wick power density, was investigated for a sintered, porous wick material. The measurements were made using distilled water.

69088 DETERMINATION OF PROPERTIES OF CAPILLARY MEDIA USEFUL IN HEAT PIPE DESIGN
E. C. Phillips and J. D. Hinderman (McDonnell Douglas Corp., McDonnell Douglas Astronautics Co., Western Div., Richland, Wash.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-18, 10 p., 9 refs., Avail:TAC. Contract No. NAS 1-8000.

Description of heat-pipe data on wick permeabilities and burnout heat fluxes. For thick wicks, some variations of permeability with flow as measured with a forced flow device indicate that Darcy's law is not quite valid. Permeabilities of thin wicks (a single layer of screen) were determined with a sloping-wick device where friction is overcome by gravity. These permeabilities vary with depths of the menisci in the openings and consequently with the pressure difference between the liquid in the wick and the gas above it. Burnout heat fluxes were measured in a device where a small wick, supplied liquid by an artery to minimize pressure variations along the wick, is uniformly heated. The burnout heat fluxes were determined for three liquids as a function of temperature and of the pressure difference between the liquid in the wick and the gas above it.

69089 PERFORMANCE OF A WICK-LIMITED HEAT PIPE
John C. Chato and Jerrold H. Streckert (Illinois, University, Urbana-Champaign, Urbana, Ill.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-20, 9 p., 8 refs., Avail:TAC. Grant No. NGR-14-005-103.

Discussion of a heat pipe with variable dimensions designed for evaluating wick performance with a well defined fluid transfer length within the heat pipe. A simple horizontal isothermal wick experiment, developed for quantitative testing of various wicking materials outside the heat pipe, is also described. The maximum steady heat transfer capability or wick "burn-out" point was 10 W for an 81.9 cm long and 18.85 cm wide Refrasil C100-28 material, using water as the working fluid at a temperature of 26.7 (plus or minus 5) deg C. In practice, it was found possible to transfer considerably more heat than the burn-out point without damage to the system. However, when the heat input exceeded this value, the temperature continued rising, and temperature differences developed in the heat pipe. The time constant of the wicking chamber was found to be much shorter than that of the heater assembly, so that meaningful direct transient tests could not be performed.

69090 LIQUID TRANSPORT PROPERTIES OF SOME HEAT PIPE WICKING MATERIALS
L. S. Langston and H. R. Kunz (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-17, 11 p., 27 refs., Avail:TAC. Contract No. NAS 3-7622.

A simplified analysis of heat pipe operation has indicated wick and fluid property parameters which are important in defining the maximum heat flux that a heat pipe can transport before failure due to capillary pumping limitations. These wick parameters were experimentally determined for a number of sintered metallic materials fabricated from felted fibers, powders, and screens. Considered as classes of materials, the fibrous materials were found to be best; the powder materials were next, and the screen materials were poorest. Both water and Freon 113 were used as working fluids to evaluate the effects of fluid properties.

70072 THE EFFECT OF WICK GEOMETRY ON THE OPERATION OF A LONGITUDINAL HEAT PIPE
Hugh Edward Kilmartin, Jr., Naval Postgraduate School, Monterey, Calif. (M.S. Thesis), Jun. 1969, 70 p., refs. (AD-692442), Avail:TAC

Evaporative heat transfer limits were obtained and studied for an everted heat pipe with varying wick geometries. The wick geometries were a function of the wire mesh size and the total wick thickness. A nickel heat pipe was built and operated using both water and ethyl alcohol as the working fluids. The different wick materials used were 50 mesh, 80 mesh, and 150 mesh, plain weave, nickel wire cloth. The scope of the investigation included operating the pipe at 25 inches mercury vacuum, 10 inches mercury vacuum, and 5 pounds per square inch gage. The maximum heat transfer was found to increase as the mesh size was decreased, as the wick thickness was increased, or as the pressure was increased. The equipment used to obtain experimental data is described and experimental results and sample calculations are presented.

70074 A STUDY OF WIRE MESH WICK CHARACTERISTICS IN A LONGITUDINAL HEAT PIPE
Oscar Jonathan Hickox, Jr., Naval Postgraduate School, Monterey, Calif. (M.S. Thesis), Dec. 1969, 71 p., refs. (AD-709108), Avail:TAC

An everted, glass-enclosed, nickel heat pipe was operated at constant volume using a nickel wire mesh wick and distilled water. The performance of the pipe was evaluated under various combinations of wick parameters. The effect of the radial evaporator capillary radius, the radial condenser capillary radius, and the evaporator wetting angle were investigated at a pressure range of 27 to 24 inches of Mercury vacuum. The performance of the pipe was found to improve with decreasing radial evaporator capillary radius and decreasing amounts of non-condensables in the working fluid. A detrimental wick-aging effect which led to violent boiling and early dryout was observed. A discussion of observed behavior presents evidence that boiling and wick fin effect may play a significant part in heat pipe operation.

71044 LIQUID TRANSPORT AND HEAT TRANSFER PROPERTIES OF HEAT PIPE WICKING MATERIALS
L. S. Langston, H. R. Kunz, Pratt and Whitney Aircraft, East Hartford, Connecticut. In: Proceedings of Joint Atomic Energy Commission/Sandia Laboratories Heat Pipe Conference, Volume I, October 1966. SC-M-66-623 (Abstract only)

The purpose of this paper is to define and present the wicking material properties that are considered to be important to the operation of a heat pipe. Three classes of wicking materials are studied: sintered metal screens, sintered metal powders, and sintered metal fibers. The porosity of these sintered materials ranges from 47.7 to 91.8 percent. Two characteristics of the wicking material are considered to limit the operation of the heat pipe. These are: (1) the capillary pumping characteristics of a wick; and (2) the evaporative heat transfer characteristics of a liquid-saturated wick. To evaluate the effect of capillary pumping characteristics, a simplified analysis of a planar wick pipe is made. The result of this analysis gives the maximum operating length of a planar wick model in terms of the external boundary conditions, the heat pipe fluid properties, and the capillary pump characteristics of the wicking material. The capillary pump characteristics are found to be proportional to the equilibrium height to which the heat pipe liquid will rise in the wicking material divided by the wicking material friction factor. The latter is the reciprocal of the permeability for the wicking material. The results of wick equilibrium height experiments and wick permeability experiments run on the three classes of wicking materials are presented. Both water and Freon 113 are used in these experiments. These results are combined to yield the capillary pumping characteristics of each wicking material tested. To evaluate the effect of the evaporative heat transfer characteristics of wicks, experimental data on porous samples selected from the three classes of wicking materials is presented. These data result from evaporative heat transfer experiments run on planar wick samples saturated with water. All experimental results are compared with the heat transfer characteristics of a flat plate submerged in water. The data indicate that the entrapment of vapor bubbles in the wick matrix may cause the premature occurrence of film boiling in the porous material at relatively low heat fluxes, depending on the structure of the wicking material.

D.3 MATERIALS

67056 ALKALI METALS EVALUATION PROGRAM
P. Y. Achener, Aerojet-General Nucleonics, San Ramon, Calif., Quarterly Progress Report, 1 Jul.-30 Sep. 1966, 30 Sep. 1966, 28 p., refs. (Contract AT(04-3)-368) (AGN-8202), Avail:TAC

Results are reported for studies on thermodynamic and transport properties of Cs, Rb, Li, and Na. Studies were made on Li and Na for heat pipe applications. The properties measured include PVT relations, vapor thermal conductivity, liquid viscosity, vapor viscosity, and specific heat for Cs and Rb and vapor pressure, surface tension and contact angle of the liquid and its vapor, liquid and vapor viscosity, and specific heat for Na and Li. Data are tabulated.

67057 ALKALI METALS EVALUATION PROGRAM
P. Y. Achener, Aerojet-General Nucleonics, San Ramon, Calif., Nuclear Products and Services Group, Quarterly Progress Report, 1 Jan.-31 Mar. 1967, May 1967, 30 p., refs. (Contract AT(04-3)-368) (AGN-8222), Avail:TAC

Developments in studies on the thermodynamic and transport properties of Rb, Cs, and K and thermodynamic and transport properties of alkali metals for heat pipe applications are described. Data are given on: PVT relations for K; vapor thermal conductivity of Rb; liquid viscosity of Li; and liquid thermal conductivity of Li and Na.

68041 LIQUID METALS FOR HEAT-PIPES, PROPERTIES, PLOTS, AND DATA SHEETS
Schins, H. E. J. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). (EUR-3653). Sept. 8, 1967. 116p. Avail:TAC

Calculation of the heat transfer in a heat-pipe requires many liquid and vapor data of the working fluid (metal) in the region of the boiling point. Measurements were made for the twelve most current metals of the vapor pressure and the surface tension. For calcium, strontium and barium density measurements were also made. The vapor pressure measurements were made with the new method of Bohdansky, using the heat-pipe effect in an open tube. Surface tension and density measurements were made by the maximum bubble pressure method. The vapor pressure measurements make it possible to evaluate the boiling point, the heat of vaporization and the vapor density. Data sheets are presented for surface tension, vapor pressure, and vapor density. Data sheets for density, viscosity, and vapor viscosity are also presented.

68042 COMPATIBILITY OF VARIOUS HIGH-TEMPERATURE HEAT PIPE ALLOYS WITH WORKING FLUIDS
Johnson, G. D., Donald W. Douglas Labs., Richland, Wash., 7th Thermionic Conversion Specialists Conf., Framingham, Mass., Oct. 1968. Avail:TAC (8p) 15 refs.

Ten working fluids and three high-temperature alloys have been investigated experimentally. A figure of merit is introduced, that is calculated from surface tension, liquid density, latent heat of vaporization and viscosity of the working fluid. This figure of merit is evaluated as a function of temperature for the working fluids and presented together with results on oxidation of the alloys.

69091 STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS FOR ADVANCED SPACE SUITS
W. Woo, TRW Systems Group, Redondo Beach, Calif., Materials Research Report, 1 Jul. 1967-1 Sep. 1968, Nov. 1968, 72 p., refs. (Contract NAS2-3817) (NASA-CR-73271; TRW-06462-6007-R000), Avail:TAC

A solution of heat pipe freeze up problems through the use of mixtures as heat pipe working fluid is presented. Data on the freezing point of mixtures of 1-propanol and water were experimentally obtained. Experimental gas emission tests of potential space suit heat pipe materials when exposed to both a vacuum environment and a water vapor environment were performed. A literature search was conducted to select film enclosure materials suitable for flexible heat pipe application with one of the desired film selection characteristics being impermeability to noncondensable gases. To reduce the thermal gradient from the heat pipe outer surfaces to the active wick surfaces, studies of the thermal conductivity of metallic wicking materials and methods of bonding wicks to substrates were performed. Techniques are described for the fabrication of an experimental heat pipe device which was used to demonstrate techniques applicable to extravehicular space suit controllable heat pipe devices for temperature control.

69092 HIGH TEMPERATURE LITHIUM HEAT PIPES
C. A. Busse, F. Geiger, H. Strub (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le Ricerche Comuni, Ispra, Italy), M. Poetzschke, and G. Kraft (Metallgesellschaft AG, Frankfurt am Main, West Germany). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969, p. 495-506. 8 refs., Avail:TAC

Study of the corrosion mechanism in high-temperature Nb-1 ZR/Li and Ta/Li heat pipes, and measurements of the heat transfer. It is found that the corrosion of the heat pipes can be caused by the oxygen content of the wall material. Promising results on corrosion inhibition were obtained (1) by using as a wall material Nb-1 Zr which was deoxidized by a heat-pipe process to below 1 ppm O, (2) by adding Ca to a Nb-1 Zr/Li heat pipe, and (3) by using Ta with a small content of Y. The Nb-1 Zr/Li heat pipes withstood tests of 1000 hr at 1500°C without failure, but considerable loss of Zr occurred. Heat transfer measurements were made with a Li heat pipe about 50 cm long and with 0.46-cm^2 vapor flow area. At 1500°C, a maximum axial heat flux density of about 15 kW/cm^2 was measured.

70075 CORROSION STUDIES OF LIQUID METAL HEAT PIPE SYSTEMS AT 1000 TO 1800 C
G. D. Johnson (Donald W. Douglas Laboratories, Richland, Wash.). Metallurgical Society of AIME, Fall Meeting, Philadelphia, Pa., Oct. 13-16, 1969, Paper F 69-2, 17 p., 23 refs., Avail:TAC
Evaluation of the compatibility of heat pipe structural alloys with different working fluids, using reflux capsules. Capsule tests with refractory metal seamless tubing have been conducted in vacuum at temperatures of 1000 to 1800 C and at times to 1000 hours. Systems evaluated to date are: TZM with indium; Cb-1Zr with lead, calcium, and barium; and Ta-10W with indium, calcium, lead, thallium, and barium. The observed corrosion behavior of the various systems is associated with the nature of oxygen in the particular system. Severe attack has been observed in the lead and thallium systems, while calcium produces very little attack, especially in contact with Ta-10W. Corrosion occurring with calcium is mainly confined to very shallow intergranular penetration.

70076 MERCURY AS A HEAT-PIPE FLUID
J. E. Deverall (California, University, Los Alamos, N. Mex.). In: Space Systems and Thermal Technology for the 70's; American Society of Mechanical Engineers, Space Technology and Heat Transfer Conference, Los Angeles, Calif., June 21-24, 1970, Proceedings. Part 2. (A70-41014 21-33). New York, American Society of Mechanical Engineers, 1970, 10 p., 7 refs. AEC-sponsored research, Avail:TAC
In order to determine the feasibility of using mercury as a heat-pipe fluid, a mercury heat pipe was put on life test for 10,000 h at 330 C to study the wetting characteristics of mercury in a stainless-steel structure. A second pipe was built and operated to determine the heat-transfer capability of a mercury system and to compare its operational limitations with theoretical limitations. The results of the tests indicated that good wetting of wick structures could be attained and that long-term operation is possible without excessive corrosion. The heat-transfer test demonstrated that mercury behaves as a normal heat-pipe fluid with regard to its operational limitations and start-up dynamics. Construction of mercury heat pipes for high heat-transfer rates appears to be feasible for operation between 200 and 360 C.

70077 REACTOR, SYSTEM, AND COMPONENT ENGINEERING
California Univ., Livermore, Lawrence Radiation Lab., (UCRL-50004-67-1, pp. 47-82), Avail:TAC
CORROSION LOOPS--design of high temperature liquid lithium for heat pipe alloy testing
HEAT PIPES--fabrication technique development for 2000°K tungsten-molybdenum alloy
LOOPS--operation of low temperature liquid NaK, for testing reactor space power system pumps
MOLYBDENUM ALLOYS AND SYSTEMS--Mo-W, fabrication technique for 2000°K heat pipe
NUCLEAR AUXILIARY POWER SYSTEMS--design concepts for 300 kW(e) and 10 MW(e) space, using Rankine cycle power conversion --radiator designs for SPR-6, analysis of direct-condensing tube-fin and heat pipe
POWER CYCLES--specific mass of 300 kW(e) and 10 MW(e) Rankine system, reactor coolant outlet temperature for minimum, (T)
PUMPS--testing of reactor space power system, low temperature liquid NaK loop for
RADIATORS--design concepts for SPR-6 system, analysis of direct-condensing tube-fin and heat pipe
REACTORS, POWER--design concepts for 300 kW(e) and 10 MW(e) space, using Rankine cycle power conversion

70078 COMPATIBILITY EVALUATION OF AN AMMONIA-ALUMINUM-STAINLESS STEEL HEAT PIPE
Waters, E. D., King, P. P., McDonnell Douglas Corp., Richland, Washington (ASME 70-HT/SpT-15 Space Technology and Heat Transfer Conf., June 21-24, 1970) Avail:TAC (10p.)
Tests were conducted to confirm the ability of an ammonia-aluminum-stainless steel heat pipe to operate for extended periods without failure either by fluid loss or by degradation of the energy transport mechanisms. Test conditions were chosen to accelerate the postulated failure mechanisms. The heat pipes were operated to simulate

particular spacecraft lifetimes of 7 to 10 years. Post-test thermal performance was compared with pre-test performance and the heat pipes were sectioned for metallographic examination. Results of the performance tests and photomicrographs of the metallurgical specimens are presented.

70079 CORROSION IN HIGH TEMPERATURE LITHIUM HEAT PIPES WITH NIOBIUM-1 ZIRCONIUM AND TANTALUM AS WALL MATERIAL
C. A. Busse, Euratom 4298.e Corrosion Science 10, 65 (1970), Avail:TAC (32p)

In Nb-1Zr or Ta heat pipes with Li as working fluid, operated at temperatures of 1500°C or 1600°C, corrosion can cause a wall perforation in the heating zone within a few hours. Analysis of such heat pipes, together with fluiddynamic and thermodynamic considerations, leads to the conclusion that the corrosion is caused by the initial oxygen content of the wall material. The corrosion mechanism consists in the transition of oxygen from the wall material of the cooling zone to the liquid Li, the transport of the oxygen to the heating zone, the local increase of the oxygen concentration in the liquid Li by the evaporation process and finally the wall attack by this oxygen-rich Li. The corrosion can be strongly reduced or completely inhibited by deoxidation of the wall material, by the addition of Ca to the Li, or of Y to the Ta.

E. TESTING AND OPERATION

65015 HIGH THERMAL CONDUCTANCE DEVICES UTILIZING THE BOILING OF LITHIUM OR SILVER
J. E. Deverall and J. E. Kemme (Los Alamos Scientific Lab., Univ. of California, N. Mex.). (LA-3211). Oct. 1964. Contract W-7405-eng-36. 33p., Avail:TAC

The "Grover Heat Pipe" is a self-contained, thermal conductance device that has no moving parts, utilizes the heat being transferred for its operation, has a thermal conductance higher than any known material, and conducts heat with essentially no temperature difference. Heat is transferred by means of mass flow of a fluid, utilizing the latent heat of a two-phase system. For high-temperature applications, two liquid metals have been tested and found suitable as heat pipe fluids: lithium and silver. Lithium heat pipes have been successfully operated up to 1300°C with heat input fluxes of 200 watts/sq cm and silver heat pipes up to 2000°C with input fluxes of over 400 watts/sq cm.

65016 A CONTROLLABLE HEAT PIPE EXPERIMENT FOR THE 5E-4 SATELLITE
Johns Hopkins Univ., Silver Spring, Md., Applied Physics Lab., Theodore Wyatt, 9 Mar. 65, 12 p. Rept. No. APL-SDO-1134. Contract NOw-62-0604, Avail:TAC

An observation was made during early heat pipe trials. An unwanted "non-condensible" gas was present in a heat pipe and it was observed that the non-condensible gas (hydrogen) was concentrated at the heat-output end of the pipe and that the amount of heat liberated over the intended output area was proportional to the amount of non-condensible gas present. This experimental finding seems to be susceptible to the following logical explanation. Assume that initially the hydrogen was uniformly distributed throughout the pipe. As heat is put into the device the working fluid (sodium) is boiled off and the resulting gas flows from the heat-input end to the heat-output end. The sodium gas flow sweeps the hydrogen to the heat-output end; as long as the heat pipe is operated any hydrogen molecules tending to migrate from the output end are returned by the comtinuing sodium gas flow. The equilibrium situation thus created is illustrated.

66031 STATUS REPORT ON THEORY AND EXPERIMENTS ON HEAT PIPES AT LOS ALAMOS
T. P. Cotter, J. Deverall, G. F. Erickson, G. M. Grover, E. S. Keddy, J. E. Kemme, and E. W. Salmi. IN: EUROPEAN NUCLEAR ENERGY AGENCY AND INSTITUTION OF ELECTRICAL ENGINEERS, INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION, LONDON, ENGLAND, SEPTEMBER 20-25, 1965. [A66-15532 05-03] 1965. 12 p., 8 refs., Avail:TAC

Survey of experiments performed on the characteristics of heat pipes. The status of corrosion studies at elevated temperatures is reviewed. A quantitative engineering theory for the design and performance analysis of heat pipes is described. The experimental investigations were divided into three temperature regimes which reflect the application areas of interest. The lowest temperature regime is of little concern for thermionic applications. Water and the alcohols are used as working fluids, and control of satellite component temperatures is one objective. The next temperature regime is from 700 to 1400°K for heat removal from the collectors of thermionic converters. While the heat transfer rates are not excessive in most applications, the lifetime requirement is long. Therefore, life testing of suitable material combinations is of importance. The high-temperature regime of 1400 to 2100°K presents the most challenging area of heat pipe application. Test heat pipe sizes ranged from 1 to 2 cm in diameter and from 10 to 43 cm in length. The capillary structure was formed from 100-mesh screen with 0.003-in.-diam wire. Lithium is an ideal heat pipe fluid because of its high latent heat of vaporization and its high surface tension. Tantalum and tantalum alloys are used as heat pipe container tubes at temperatures above 1500°C. Examination of a sectional heat pipe after operation with silver for 100 hr at 1900°C was made. The total mass of silver circulated during this period was 200 kg. Estimates based on three pipes operated at 1900°C gave mass transport rates between 2 and 4 x 10^{-9} grams per joule of heat transferred. These rates indicate a tantalum solubility in silver of the order of 10 ppm.

66032 RCA TESTS THERMAL ENERGY PIPE
John F. Judge, Missiles and Rockets, Feb. 21, '66 Avail:TAC (3p)

The development and tests with results on a molybdenum heat pipe, designed to transfer thermal energy from heat sources to thermionic devices for direct conversion into electricity are presented. The RCA design is shown to eliminate all moving parts and does not depend on gravity.

66033 HEAT-PIPE EXPERIMENTS
Hall, W. B., IEEE-Thermionic Conversion Specialist Conference--Report Oct 25-27, 1965, p. 337-40 Avail:TAC

Heat pipes used for transport of heat in thermionic power supply devices; report of two tests, namely high-thermal-flux-transfer test and heat-flux-concentration test; on basis of tests it is claimed that heat pipe can supply sufficient heat flux to drive thermionic converter, and that it acts as a thermal transformer and provides high thermal heat transfer.

67058 ADVANCED REACTOR TECHNOLOGY (ART)
Los Alamos Scientific Lab., N. Mex., Quarterly Status Report for Period Ending Oct. 31, 1966, Nov. 1966, 28 p., refs. (Contract W-7405-ENG-36) (LA-3625), Avail:TAC

Installation of UHTREX plant and instrumentation systems is nearly complete. Analytical studies of the planned program of transient experiments have begun. Summaries are included concerning the development status of the reactor components. Work in the Na-cooled reactor program includes instrumentation testing and development, heat transfer investigations and formulation of computer programs for treating the dynamic response of entire reactor plants. Plasma thermocouple work was devoted to measurements of Cs vapor pressure, development of insulation for thermionic fuel rods, investigations of stability and fabrication of Tm_2O_3-Mo thermionic fuels, and calculations on performance of cylindrical diodes. Heat pipe tests were conducted using 80-cm-long pipes containing Na. A heat transfer limit of 5500 W at 850°C was determined. Fabrication methods for W heat pipes were investigated. A summary of investigations concerning thermal neutron effects on liquid Pu fuels is included. Fabrication and properties of Ta and Nb-base materials for Pu capsules were studied.

67059 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
J. K. Ferrell and A. Carnesale, North Carolina State Coll., Raleigh, Quarterly Progress Report, 1 Oct. 1966, 20 p. (Contract AT(40-1)-3411) (QPR-5;TID-23503), Avail:TAC

A stainless steel heat pipe was designed to obtain an understanding of the mechanisms involved in the operation of a heat pipe, to predict the operational characteristics, and to establish a procedure for the engineering design of heat pipes. Experiments were carried out with stainless steel beads to determine void fraction, permeability, and capillary rise height for various ranges of bead size. These characteristics are relevant to heat pipe operation.

67060 THERMAL MEASUREMENTS OF A THERMIONIC-CONVERTER/HEAT-PIPE SYSTEM
P. K. Shefsiek (Radio Corporation of America, RCA Electronic Components and Devices Div., Lancaster, Pa.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, THERMIONIC CONVERSION SPECIALIST CONFERENCE, HOUSTON, TEX., NOVEMBER 3, 4, 1966, CONFERENCE RECORD. [A67-22330 09-03]. Conference sponsored by the Electron Devices Technical Professional Group of the Institute of Electrical and Electronics Engineers. New York, Institute of Electrical and Electronics Engineers, Inc., 1966, p. 169-174. Contract No. NASw-1254, Avail:TAC

Description of the results of calorimetric measurements made on a converter, a prototype cylindrical device with an emitter area of 50 cm^2 designed expressly for operation from a heat pipe. The experimental method is discussed, and the results of the net electron cooling of the emitter, the effective thermal emissivity, the cesium conductance between emitter and collector, and the complete thermal balance are described. Unusually low-emitter cooling was observed in the obstructed mode of operation. The implications of such a low emitter cooling are discussed.

67061 ADVANCED REACTOR TECHNOLOGY (ART)
Quarterly Status Report for Period Ending April 30, 1967. (Los Alamos Scientific Lab., N. Mex.). May 1967. (LA-3708 (Pt. 1)) Contract W-7405-eng-36. 18p. Avail:TAC

The various systems of UHTREX are discussed. The cold flow tests on the coolant system are described. Check-out of the computer systems, and programs for use in operation are mentioned. Estimates of reactivity worths of fuel mass and poison additions are discussed. Calculations of UHTREX transient responses are described. Reactivity calculations are tabulated. Fuel particle self-shielding calculations are compared for various types of analyses. The fuel elements, and tests planned for these, are discussed. The development of the fission-couple thermopile device for use as a neutron flux monitor is discussed. A method for nondestructive activation analysis for O in Ge is presented. Tests on vertical heat pipe operations are discussed.

67062 ADVANCED REACTOR TECHNOLOGY (ART). PART I
Quarterly Status Report for Period Ending July 31, 1967. (Los Alamos Scientific Lab., N. Mex.). Aug. 1967. Contract W-7405-eng-36. LA-3760. 15p. Avail:TAC

Cold critical experiments on UHTREX are discussed. Reactivity calibration of control rods and fuel elements are presented. Results of particle self-shielding calculations are evaluated. Stability and feed back calculations are discussed; results are tabulated. Heat pipe testing and evaluation are presented.

68043 THE EFFECT OF VIBRATION ON HEAT PIPE PERFORMANCE
J. E. Deverall, Los Alamos Scientific Lab., N. Mex., 22 Nov. 1967, 7 p., refs.

(Contract W-7405-ENG-36) (LA-3798, UC-38) Avail:TAC

A water heat pipe was operated while being subjected to typical sinusoidal and random vibrations encountered during a missile launch to determine the effect of vibration on heat pipe performance. The results of the experiment indicate that vibration tends to improve heat pipe performance as it promotes better wetting of the wick structure by the fluid.

68044 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT
P. Brosens, Thermo Electron Engineering Corp., Waltham, Mass., Final Report, 23 Jun. 1966-6 Nov. 1967, Dec. 1967, 115 p., ref. Prepared for JPL. (Contracts NAS7-100; JPL-951465) (NASA-CR-93664; TE4067-61-68) Avail:TAC

Four heat pipe models, designated T/E-1 through T/E-4 were designed, fabricated, and subjected to a heat transfer test, a thermal cycling test, and a 100-hour run at maximum heat load. Model T/E-1 failed after the heat transfer test due to an embrittling reaction that occurred after assembly between the niobium heat pipe wall and its radiative coating. Model T/E-2 failed after the heat transfer test due to a faulty capillary assembly which caused overheating and a failure at the heat pipe-collector junction. Model T/E-3, fabricated with an emitter structure and operated as a converter, yielded valuable data on converter radiator heat load for accurate heat pipe sizing. This model completed the thermal cycling test and a 400-hour run at maximum load. Model T/E-4, without an emitter structure, had a larger radiator area than the other models and could accommodate an output current of 71.5 amperes at the optimum collector temperature. The model completed all the tests successfully, resulting in a heat pipe collector-radiator suitable for incorporation in the advanced SET converter.

68045 HEAT PIPE PERFORMANCE IN A SPACE ENVIRONMENT
J. E. Deverall and E. W. Salmi, Los Alamos Scientific Lab., N. Mex. [1967] 4 p., refs. Presented at the IEEE Thermionic Conversion Specialist Conf., Palo Alto, Calif., 30 Oct.-1 Nov. 1967. (Contract W-7405-ENG-36) (LA-DC-9028, CONF-671045-3) Avail:TAC

The unusual thermal characteristics of the heat pipe indicate that it has great potential for the solution of heat transfer problems in satellites. In order to demonstrate that heat pipes will function normally under space conditions, a water heat pipe was launched into an earth orbit by an Atlas-Agena vehicle to determine the effect of a zero-gravity field on its operation. A second experiment was conducted in which a similar heat pipe was subjected to typical sinusoidal and random vibrations experienced by a satellite during the missile launch period. The results of the experiments indicate that heat pipes are suitable for space applications.

68046 HEAT PIPE STARTUP DYNAMICS
T. P. Cotter, Los Alamos Scientific Lab., N. Mex. [1967] 5 p., ref. Presented at the IEEE Thermionic Conversion Specialist Conf., Palo Alto, Calif., 30 Oct.-1 Nov. 1967. (LA-DC-9026; CONF-671045-2) Avail:TAC

Transient modes of heat pipe startup are described. The heat flux-temperature states, the flow properties during startup, and the various mechanisms which may inhibit successful startup are discussed quantitatively.

68047 VAPOR CHAMBER FIN STUDIES. OPERATING CHARACTERISTICS OF FIN MODELS
H. R. Kunz, S. S. Wyde, G. H. Nashick, and J. F. Barnes, Pratt and Whitney Aircraft, East Hartford, Conn., Washington, NASA, Aug. 1968, 95 p., refs. (Contract NAS3-7622) (NASA-CR-1139; PWA-3154) Avail:TAC

This report presents the test results from experiments on two vapor-chamber fin (heat pipe) geometries and compares these results with a theory developed and presented in a prior report. Typical temperature distributions were obtained for heat pipe operation plus limiting heat flux data which was compared to the theory. This comparison indicated that the theory showed the correct trends at low levels of heat flux. An effect of working fluid inventory was found which was not included in the present theory. Tests with a noncondensable gas present in the chamber were found to result in complete mixing of this gas with the working fluid vapor.

68048 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
Ferrell, J. K. (North Carolina State Univ., Raleigh). Report on Progress During the Ninth Quarter. (ORO-3411-9), Nov. 1, 1967. Contract AT(40-1)-3411. 13p. Avail:TAC

The design of an experimental apparatus to study heat transfer to wetted porous beds at atmospheric and elevated pressures (up to 200 psi) has been completed and the apparatus is under construction. The solution technique for the distribution of pressure, mass flux, temperature and heat flux in a flat-plate heat pipe is discussed.

68049 STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
Ferrell, J. K.; Schoenborn, E. M. (North Carolina State Univ., Raleigh). Report on

Progress During the Eleventh Quarter. (ORO-3411-11), Apr. 1, 1968. Contract AT(40-1)-3411. 23p. Avail:TAC

Progress to date on two general experimental programs relating to the operating characteristics of the heat pipe is summarized. The apparatus that has been constructed, the experimental method employed, and the results obtained in the continuing study of heat transfer through porous media are described. Data are presented on the boiling of water at atmospheric pressure in an immersed bed of monel particles (40 to 50 mesh) supported on a stainless steel electrically heated surface. The equipment, experimental approach, and results obtained on the controlled environment heat pipe are described. Heat fluxes and temperature differences in the evaporator section of the apparatus were determined at atmospheric pressure using water in a capillary bed of the same particles. Angle of inclination of the capillary wick to the horizontal was the parameter of primary interest. A comparison of the results shows surprising similarities at low heat fluxes and small temperature differences.

68050 HEAT-PIPE PERFORMANCE IN A ZERO GRAVITY FIELD
Deverall, J. E. (Los Alamos Scientific Lab., N. Mex.); Salmi, E. W.; Knapp, R. J. Contract W-7405-eng-36. J. Spacecraft Rockets, 4: 1556-7 (Nov. 1967). (LA-DC-8844), Avail:TAC

A heat pipe is a sealed container in which a fluid is continuously evaporating and condensing, thereby establishing a two-phase system resulting in an essentially constant temperature throughout the length of the container. Heat addition into the evaporator section of the heat pipe is distributed throughout the other section by flow and condensation of vapor. Completion of the cycle is obtained with the return of the condensate to the evaporator by capillary action through a wick structure lining the container wall. Thus, large quantities of heat can be transferred with essentially no temperature difference and at a fraction of the weight of an equivalent solid heat conductor. By proper choice of fluids, heat pipes can be constructed for operating temperatures from below 0° to 2000°C; they appear to have great potential for solution of heat transfer problems in space applications. An experiment was conducted to demonstrate that a heat pipe will operate normally in the absence of gravitational forces. The necessary evidence to substantiate this fact was considered to be isothermal operation of a water heat pipe while in an earth orbit. The satellite module, in which the heat pipe was mounted, was launched from Cape Kennedy April 5, 1967, on an Atlas-Agena vehicle.

68051 QUARTERLY STATUS REPORT ON THE SPACE ELECTRIC POWER R AND D PROGRAM FOR THE PERIOD ENDING JULY 31, 1968. PART I.
Los Alamos Scientific Lab., N. Mex. (LA-3986), Aug. 23, 1968. Contract W-7405-eng-36. 6p. Avail:TAC

Heat transfer experiments with Na and K in annular return heat pipes have shown that large capillary forces can develop in such a pipe if a tube of five porosity separates the liquid return path from the vapor passage. The procedure for fabricating porous tubes from several layers of five-mesh screen is described. Methods for determining the pore size of the tubes and the capillary force that can develop in the finished product are discussed.

68052 QUARTERLY STATUS REPORT ON THE SPACE ELECTRIC POWER R AND D PROGRAM FOR THE PERIOD ENDING APRIL 30, 1968. PART I.
Los Alamos Scientific Lab., N. Mex. (LA-3941), May 22, 1968. Contract W-7405-eng-36. 7p. Avail:TAC

Construction techniques and heat transfer results for annular return heat pipes are described. Tests were run to determine axial heat flow rates using potassium and sodium as working fluids in SS heat pipes with SS screens with exit temperatures up to 800°C. Indium was tested as a working fluid in a Re heat pipe with a W screen at 1950°C for 1000 hr. Re and W were found to be soluble in indium. Silver was tested as a working fluid in a Re heat pipe with W screen at 2000°C for 373 hr. Interdiffusion between Re and W occurred on the inner surface of the heat pipe. An incomplete test was made using phenyl ethyl as a working fluid in a SS heat pipe.

68053 DESIGN AND OPERATION OF A HEAT PIPE
Master's thesis, Naval Postgraduate School, Monterey, Calif. Rufus Thurman Burges, Jr. Jun 68, 44p. Distribution Limitation now Removed, Avail:TAC

An experimental stainless steel heat pipe using water as the working fluid and 400 mesh stainless steel screen for a wick was designed and tested to determine the effect of gravity and nucleate boiling on heat pipe performance. The results of heat pipe operation at various angles of inclination in a gravity field are presented and compared with the existing theoretical predictions. The maximum heat flux obtained experimentally at angles of inclination less than 90 degrees was less than the predicted value by a factor of two or three. The maximum heat flux obtained for an angle of inclination greater than 90 degrees was much higher than that predicted. In addition, nucleate boiling noise was detected during operation at angles of inclination greater than 90 degrees.

68054 LOW TEMPERATURE HEAT PIPE RESEARCH
Phillips, E. C., Jr., Holmgren, J. S., Madsen, J. Donald W. Douglas Labs., Richland, Wash. (DAC-60752P) July 1968 Avail:TAC (55p) 11 refs.

This report summarizes independent research and development (IRAD) effort including investigations of the use of arterial capillary flow passages in low temperature (250°F) water devices. The use of low temperature heat pipes to cool spacecraft electrical components, thermally control other components such as external sensors, hatches, or heat storage devices, and thermally equalize the outer shell of space vehicles were investigated. Preliminary performance analysis indicates the need for heat pipe operation over long distances, particularly for the case of thermal equalization of manned spacecraft. Thus, investigations proceeded with analysis and definition of bypass wick configurations including use of the artery. The feasibility and advantages of the artery have been successfully demonstrated by experimental tests.

68055 HEATPIPE LIFETESTS AT 1600°C AND 1000°C
Busse, C. A., Geiger, F., Poetzschke, M., Quataert, D., IEEE--Thermionic Conversion Specialist Conference--Conference Rec Nov 3-4 1966 p 149-58 Avail:TAC

A series of life tests at 1600°C were performed with Li, Pb, Tl, Bi, and Ba as working fluids and Cb-1Zr Ta and W as wall materials; three of these systems proved to be promising for operation longer than 1000 hr at 1600°C--W/Li, W/Pb, and SGS-Ta/Tl; in 1000°C region life tests with Cb-1Zr and Li (3570 hr at 1000°C), Na (1000 hr at 1100° C) and Cs (1000 hr at 1000°C) were made.

69093 DEVELOPMENT OF A VERSATILE SYSTEM FOR DETAILED STUDIES OF THE PERFORMANCE OF HEAT PIPES
J. H. Streckert and J. C. Chato, Illinois Univ., Urbana, Dept. of Mechanical and Industrial Engineering, Dec. 1968, 49 p., refs. (Grant NGR-14-005-103) (NASA-CR-100725; ME-TR-64) Avail:TAC

A heat pipe with variable dimensions was designed for the study of steady state and transient heat pipe performance using different fluids and wicking materials. An open ended dewar was designed and constructed for housing the heat pipe system. The maximum length of wicking material was 82 cm; this distance was considered the maximum length of heat transfer required in future space suits. Distilled water was the transfer medium used in the wicking chamber. The heat input to the dewar was supplied by electric heaters. Circulation of cool water was used to remove heat from the condenser end of the dewar. Approximately 45 thermocouple points were used for measuring important temperatures in the system. Throughout the entire wicking chamber, a maximum temperature variation of 1/2°C was encountered during normal heat pipe operation. No transient temperature lag from one end of the wicking chamber to the other end was observed during heat input changes. Apparently the time constants of the heat input changes were much larger than the temperature equalizing time constant of the wicking chamber.

69094 LOW-TEMPERATURE HEAT PIPE RESEARCH PROGRAM
E. C. Phillips, McDonnell-Douglas Astronautics Co., Santa Monica, Calif., Western Div., 24 Jun. 1969, 116 p., refs. (Contract NAS1-8000) (NASA-CR-66792, DAC-63366) Avail:TAC

Basic data for use in design and analysis has lagged for heat pipes operating in the range from +100° to +200°F for thermal management of spacecraft. Of most importance are wick fluid flow and evaporator performance data. Wick permeabilities and capillary pressures were measured for wicks ranging in thickness from 0.005 to 0.100 in and structures ranging from square mesh screen to metal foams and felts. Permeabilities were also measured as a function of the menisci radii in the liquid/vapor interface. Forced flow and gravity flow measurement techniques were used. Results are presented in graphic form as a function of flow per unit area. Permeability data were found to deviate slightly from Darcy's law. Evaporator performance was determined by measuring maximum evaporator heat fluxes for metal screen, felt, and foam wick structures with water, methanol, and butanol. Heat fluxes were measured in the vapor and at the vapor pressure of the working fluid. Maximum heat fluxes at operating temperatures of approximately 100° and 150°F in the vapor of the working fluid were found to be lower than those measured in air at atmospheric pressure. Heat pipe design procedures are outlined which make use of the wick permeability and evaporator heat flux data. Figures of merit for various potential working fluids are presented.

69095 AN EXPERIMENTAL AND ANALYTICAL STUDY OF WATER HEAT PIPES FOR MODERATE TEMPERATURE RANGES
National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala. Billy Grant McKinney (Ph.D. Thesis - Ala. Univ.), 6 Jun. 1969, 164 p., refs. (NASA-TMX-53849) Avail:TAC

Eight water heat pipes used as radiating fins and eight water heat pipes having an adiabatic section and a condenser were investigated while in or near a vertical position. Different heat inputs were applied to maintain steady-state operation of the heat pipes at temperatures of approximately 200°, 250°, 300°, and 350°F. A data acquisition system was used to record heat inputs, surface temperatures, interior temperatures, and pressures of the heat pipes. The equations governing heat pipes were developed and programmed for a digital computer in order to study the effects of permeability, apparent contact angle, and length of the adiabatic section contained as parameters in the equation. The solutions for the equations and the parametric studies are presented in graphs. Design and fabrication of the heat pipes are described. A high-altitude simulation system was used for testing the water heat pipes as radiating fins. The analytical results were found to agree with experimental data in the temperature range from 200° to 350°F.

69096 EXPERIMENTS WITH A TWO-FLUID HEAT PIPE
K. T. Feldman, Jr. (New Mexico, University, Mechanical Engineering Dept., Albuquerque, N. Mex.) and G. L. Whitlow (Energy Conversion Systems, Inc., Albuquerque, N. Mex.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03). Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 1025-1032, 7 refs. Research supported by the Energy Conversion Systems, Inc.; NSF Grant No. GY-4620, Avail:TAC

The experimental performance of a two-fluid heat pipe, using methanol and water, was evaluated over a range of operating conditions. Temperatures along the heat pipe and condenser end vapor pressures were measured for two thermal power input conditions. Five ratios of working fluids were tested from 100 per cent water to 100 per cent methanol. The experimental results indicate that a two-fluid heat pipe is not isothermal. The two fluids separate into relatively isothermal regions with the more volatile fluid in the condenser end of the heat pipe. The location of the transition region depends on the mass ratio of the two fluids and on the operating temperature. Data indicate that the practical operating temperature range and heat transport rate capacity of a water heat pipe can be increased by the addition of a small quantity of methanol in the working fluid.

69097 PERFORMANCE MAP OF THE WATER HEAT PIPE AND THE PHENOMENON OF NONCONDENSIBLE GAS GENERATION
Joe Schwartz (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-15, 11 p., 7 refs., Avail:TAC

Assessment of a series of heat pipe performance curves which are an integral part of a performance map. The test heat pipe is cylindrical in shape and has stainless-steel components; water is the working fluid. The accumulation of free hydrogen, a noncondensable gas, was observed to occur in the heat pipe. A postulation of this phenomenon is presented, and conclusions are drawn.

69098 NEUTRON RADIOGRAPHIC EXAMINATION OF VAPOR BUBBLE FORMATION AS A LIMITATION ON PLANAR HEAT PIPE PERFORMANCE
Moss, Richard Alan. Princeton, N.J.; Princeton Univ., 1968. 145p. Thesis

An experimental study of the limiting heat transfer conditions in a planar heat pipe using water as a working fluid was conducted. The apparatus was designed to study the boiling processes that occur in the wick structure of a heat pipe. The vapor blanket which formed in the porous medium, i.e., the wick, during heat transfer was experimentally examined using neutron radiography. The neutron source for these experiments was the Industrial Reactor Laboratories' 5 megawatt reactor. The neutron radiographic system was composed of the following basic elements: a beam tube, the object (a planar heat pipe), a neutron image intensifier tube, and image recording cameras. Using the image intensifier, it was possible to quantitatively measure the thickness of water present to ±.006 inches for thicknesses up to .125 inches. The imaging system has a lateral resolution of .0135 inches. Two heat transfer models were postulated and analytically formulated. One model assumed that evaporation occurred only from the upper surface of the wick, the second assumed that vapor was generated at the base of the wick and released solely from the sides of the wick. The data taken under conditions of varying heat transfer rate and angles of wick inclination demonstrated that, with a secondary assumption of variable pore size, the second model was more realistic than the first. The basis for the assumption of variable pore size is suspected to be a result of the "Leverett effect." The effects of wick cleaning, contact angle, and pore size distribution are also discussed.

70080 THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND ORBIT
Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md., R. E. Harkness, Apr. 1969, 37 p., refs. Sponsored in part by NASA. (Contract NOw-62-0604-c) (NASA-CR-107686; AD-693028; TG-1049) Avail:TAC

The GEOS-2 Spacecraft is the first satellite to be equipped with a heat pipe as an integral part of the thermal design. The heat pipe, a device of extremely high effective thermal conductivity, is employed to minimize the temperature differences between transponders located in opposite quadrants of the spacecraft. Measured heat transfer rates through the pipe of as much as 64 watts, together with small temperature gradients on the outside of the heat pipe, are evidence of proper operation. Based on a 145-day observation period, transponder maximum and minimum temperatures show significant improvement over those of GEOS-1.

70081 PRELIMINARY PROGRAM PLAN HEAT PIPE PARAMETRIC DATA
McDonnell-Douglas Co., Richland, Wash., Donald W. Douglas Labs., J. S. Holmgren, Aug. 1969, 22 p., refs. (DWDL-698-008) Avail:TAC

A program is described which is designed to provide parametric heat pipe performance data which can be used by spacecraft designers, with only a limited knowledge of heat pipe theory, to perform tradeoff studies and generate preliminary system designs. The type of data to be generated and the basis for the selection of components and the range of parameters to be investigated are described. Parametric curves of thermal performance and weight are generated as a function of temperature and various other parameters such as length and thermal input profile. In addition, parametric data for controllable heat pipes are developed. Heat pipe operation is discussed where the basis for design data is shown. DWDL experience and facilities available for successful performance of this program are presented.

70082 THE PERFORMANCE OF A SODIUM HEAT PIPE
T. I. McSweeney (Pacific Northwest Laboratory, Richland, Wash.). American Institute of Chemical Engineers and American Society of Mechanical Engineers, National Heat Transfer Conference, 11th, Minneapolis, Minn., Aug. 3-6, 1969, AIChE Preprint 7, 19 p., 12 refs. Avail:TAC

Experimental investigation of the ease of wick resetting, the reproducibility of the dryout limit, the ability of theories to predict dryout, and the sensitivity of the wick structure to premature dryout in a sodium heat pipe with a wick structure consisting of wire-wrapped rods. Continuous monitoring of the vapor temperature at any location where vapor was flowing proved to be a sensitive means of determining both partial and total dryout of the evaporator region of the heat pipe. A wire wrap wick design, experimentally tested for the first time, is believed to be superior to a more conventional wick configuration. Unexpected operational characteristics were observed when all the heat pipe energy being transferred was concentrated into a small region. A large thermal gradient, accompanied by temperature oscillations, was observed. Calculations of the pressure drops in the vapor appear to greatly underestimate the actual driving force. Values of the pressure gradient obtained by relating the temperature differences to absolute pressure changes using the vapor pressure curve gave more rational results, but it is thought that these values may be too high.

70083 THE EFFECT OF LONGITUDINAL VIBRATION ON HEAT PIPE PERFORMANCE
Charles A. Whitehurst, Gerald D. Whitehouse (Louisiana State University, Baton Rouge, La.), and John Wilson Richardson. Journal of the Astronautical Sciences, vol. 17, Mar.-Apr. 1970, p. 249-266, 14 refs., Avail:TAC

An experimental heat pipe was constructed and performance tested while simultaneously being subjected to simple harmonic vibrations in the longitudinal direction. The frequency ranged from 0 to 580 cycles per second, and the acceleration from 0 to 12 g. Experimental tests were made to determine if the longitudinal vibration had significant effect on the performance of the heat pipe as indicated by failure of the capillary pump (drying of the wick). Secondary objectives were to determine what trends could be observed from varying frequency and acceleration of the imposed vibration. Results indicated that the vibrations caused the maximum heat transfer capacity of the heat pipe to decrease. The effect appears to be more severe at the lower test frequencies (60 cps and 120 cps) than at the higher test frequencies (240 cps and 580 cps). The severity of the reduction in maximum heat transfer capacity appears to increase as the acceleration level of the imposed vibration increases.

70084 NEUTRON RADIOGRAPHIC STUDY OF LIMITING PLANAR HEAT PIPE PERFORMANCE
Moss, Richard A. (Massachusetts Inst. of Tech., Cambridge); Kelly, Arnold J. Int. J. Heat Mass Transfer; 13: 491-502 (Mar 1970), Avail:TAC

A condition limiting the maximum heat transfer rate attainable by heat pipes was investigated experimentally. Using neutron radiographic techniques, a detailed investigation of the vaporization processes which occur interior to the wick structure of a planar heat pipe employing water as a working fluid was conducted for a number of wicks having different mean pore sizes and for several angles of inclination of the wick. The neutron radiographic system employed permitted measurements of the liquid layer thickness in the wick to be made with an accuracy of 0.006 in. for thicknesses up to 0.125 in. of water, and with a lateral resolution of 0.0135 in. Two models of the heat transfer process occurring in planar heat pipes were postulated and analytically formulated. The first model assumed that evaporation occurred only from the upper surface of the wick whereas the second assumed that vapor was generated at the wick's base and released solely from the sides of the wick. With a secondary assumption of variable pore size, the second model proved to be more realistic for correlating the test data than the first. The apparent variation of pore size, indicated by the data to be a function of heat transfer rate, was interpreted as a manifestation of the "Leverett effect."

70085 THE EXPERIMENTAL DESIGN AND OPERATION OF A ROTATING WICKLESS HEAT PIPE
Master's thesis, Naval Postgraduate School, Monterey, Calif., Thomas James Daley, Jun 70, 60p., Avail:TAC

An experimental rotating wickless heat pipe apparatus was designed and machined. The apparatus includes a rotating heat pipe assembly, test stand, spray cooling assembly, safety shielding, and instrumentation. A revised condensing limit for the operation of the rotating heat pipe was obtained by modifying Ballback's Nusselt film condensation theory to include the effects of a thermal resistance in the condenser wall and in the condenser outside surface cooling mechanism. Approximate results, obtained for half-cone angles of 1, 2, and 3 degrees, show that less heat can be removed than originally predicted by Ballback, and that the outside heat transfer coefficient can significantly alter the condensing limit. An improved Nusselt theory was developed which applies for all half-cone angles, and which includes the effects of the thermal resistances in the condenser wall and in the condenser outside surface cooling mechanism. This formulation led to a second-order non-linear differential equation for the film thickness which was numerically integrated using a free-overfall boundary condition at the condenser exit. Results obtained for a half-cone angle of 0 degrees are substantially less than the results obtained from the approximate solution for half-cone angles of 1, 2, and 3 degrees.

70086 CONSTRUCTION AND TEST OF A FLEXIBLE HEAT PIPE
Bliss, F. E., Jr., Clark, E. G., Jr., Stein, B. Sanders Associates Inc., Nashua, N.H. (ASME HT/SpT-13. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (7p), 6 refs.

A flexible heat pipe was evaluated to determine its operating characteristics (a) while stationary with varying degrees of bend and (b) while undergoing transverse and longitudinal vibration in an unbent mode. The vibrational environments varied in frequency from 5 to 1000 cps and accelerations up to 7 g's. The heat-pipe operation changed somewhat due to bending and vibration, one effect being an increase in the maximum horizontal heat-transfer capacity. Also, a reduction was noted in the wick pumping capacity when the heat pipe was operated with the evaporator above the condenser.

70087 STEADY-STATE AND TRANSIENT PERFORMANCE OF HOT RESERVOIR GAS-CONTROLLED HEAT PIPES
Marcus, B. D., Fleischman, G. L. TRW Systems Group, Redondo Beach, Calif. (ASME 70-HT/SpT-11. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (9p) 5 refs.

The effects of working fluid, in either the liquid or vapor state, within the reservoir of hot reservoir gas-controlled heat pipes were investigated. It is experimentally shown that (a) the presence of liquid in the reservoir at start-up results in temporary pressures and temperatures considerably in excess of design conditions and (b) diffusion of working fluid vapor through the control gas plays a very large role in the transient response of such heat pipes. A characteristic equation derived for the steady-state operation of such heat pipes is based on a sharp front-no axial conduction model. Experimental results demonstrate that axial conduction is very important and should be included in the analysis. Although the no-conduction model results in only a small error at the low end of the heat pipe's control range, this error grows quite large at the higher end where the model seriously underestimates the partial pressure of vapor within the reservoir.

70088 PERFORMANCE MAP OF AN AMMONIA (NH_3) HEAT PIPE
Schwartz, J. California Institute of Technology (ASME 70-HT/SpT-5. Space Technology and Heat Transfer Conf. June 21-24, 1970) Avail:TAC (10p), 7 refs.

This paper presents a series of heat pipe performance curves, which are an integral part of a performance map. The test heat pipe is cylindrical and has stainless-steel components; ammonia is the working fluid. The test data are compared to those obtained for a similar heat pipe with the same physical dimensions, but with water as its working fluid. A performance map comparison between both heat pipes indicates that the ammonia pipe was more efficient in transporting thermal loads than the water pipe, up to an operating temperature of approximately 90F. Above this temperature, the ammonia pipe's relative advantage decreased rapidly until the onset of dryout at which point the water pipe was able to transport 30 percent more thermal power than its ammonia counterpart.

70089 DEMONSTRATION OF OPERATION OF ROTATING HEAT PIPE
(Bulletin NASA Lewis Research Center. Revised 04/16/70) Avail:TAC (11p), 2 refs.

Operation of a small, non-capillary, rotating heat pipe was successfully demonstrated in a vertical mode working against gravity; water was used as test fluid, and internal thermal conductance was found to be very high.

70090 UNSTEADY OPERATING BEHAVIOR OF HEAT PIPES
Groll, Manfred and Zimmerman, Peter Chem-Ing-Tech 1970, 42(16). Avail:TAC, 4p (Ger.)

The behavior of heat pipes (rate of change of temp., pressure conditions) when brought into operation is described qual. Anal. solns. for the calcn. of the temp-time relation are given for the case where a flow of vapor has been set up. Further, irregular and steady changes in the heating performance were investigated for heat pipes made of steel, of Cu, and of Al, assuming convective cooling.

71029 REEXAMINATION OF HEAT PIPE STARTUP
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, Peter M. Sockol and Ralph Forman [1970] 4 p., refs. Presented at the 1970 Thermionic Conversion Specialist Conf., Miami, Fla. 26-29 Oct. 1970; sponsored by IEEE. (NASA-TM-X-52924) Avail:TAC

Visual observation in a lithium heat pipe of the high temperature profiles during startup were made. Cotter's model of the startup process is reassessed in the light of these observations. The model is modified by moving the sonic point to the end of the hot zone and including the opposing effects of wall friction and condensation on the flow. Transient measurements have been made on a lithium heat pipe for startup to temperatures in the range 1000 to 1400 C. As predicted by the theory, the temperature of the hot zone is fairly independent of the power input to the evaporator until the hot zone reaches the end of the pipe. The hot zone temperature predicted by the theory is 50 to 80 C higher than the measured value with up to 30 C of the discrepancy attributable to the measurement.

71030 EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE OF VARIOUS WICK CONFIGURATIONS IN SINGLE AND TWO FLUID HEAT PIPES OPERATING IN THE GRAVITATIONAL FIELD
Illinois Univ., Urbana, Engineering Experiment Station, D. L. Hunsberger and J. C. Chato, Oct. 1970, 46 p., refs. (Grant NGR-14-005-103) (NASA-CR-111760; ME-TR-187) Avail:TAC

In one study, wicking material tests were made on 9 in. by 1 in. Refrasil strips. Displacement-time curves were extrapolated for predicting the performance of a 21-3/4 in. heat pipe. In a second study, heat pipe tests were run with a well-defined wick length of 21-3/4 in. and a total width of 7 in. The same Refrasil was the wicking material. An open-ended dewar housed the heat pipe system which consisted of heat input, mass transfer, and heat removal sections. Two electric heaters supplied heat input, while circulating water was used for heat removal. Both studies showed water to be a much better operating fluid than ethyl alcohol or 50 percent ethyl alcohol by weight. Ethyl alcohol appeared to be only slightly better than the 50 percent mixture. At zero degrees the maximum heat transfer capacities were 15, 4, and 2 watts, respectively, for the three fluids. The predicted wattages in the first study were generally higher due to greater ease in saturating the wicking material with fluid. A gap effect created by sewing two layers of wicking material together greatly enhanced the heat pipe performance. At zero degrees, water transferred over 80 watts, as compared to 15 watts previously.

71031 MEASUREMENTS OF FILM CONDENSATION HEAT TRANSFER COEFFICIENTS ON VERTICAL TUBES FOR NITROGEN, HYDROGEN, AND DEUTERIUM
Ewald, Rolf; Perroud, Paul (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). [1970]. 21p. (CEA-CONF-1634) (CONF-700628-1). Avail: TAC. From Cryogenic Engineering Conference, Boulder, Colo.

Experiments carried out with a Frigoduc or cryogenic heat pipe (i.e., a device composed of a boiler connected to a condenser by a pipe through which a cryogenic fluid flows) have made possible the study of heat exchange phenomena at the condenser wall. The condensation surface is made of vertical smooth stainless steel tubes containing a cryogenic liquid boiling under constant pressure. On the external surface, vapor of the same fluid coming from the boiler (except for deuterium, where liquid hydrogen was used to condense the vapor) is condensed under a pressure depending on the exchanged thermal power. After a brief review on the techniques used, tables and curves for nitrogen, hydrogen and deuterium heat fluxes are presented as a function of the temperature variation at bulk saturation, as well as heat transfer coefficients.

71032 SONIC LIMITATIONS AND STARTUP PROBLEMS OF HEAT PIPES
Deverall, J. E.; Kemme, J. E.; Florschuetz, L. W. (Los Alamos Scientific Lab., N. Mex.). (LA-4518) Sep 1970. Contract W-7405-eng-36. 25p., Avail:TAC

71033 INVESTIGATION OF HEAT AND MASS TRANSFER IN A HEAT PIPE WITH A SODIUM COOLANT
Ivanovskii, M. N.; Sorokin, V. P.; Subbotin, V. I.; Shustov, M. V. High Temp. (USSR) (Engl. Transl.); 8: 299-304 (Mar-Apr 1970). Translated from Teplofiz. Vys. Temp.; 8: 319-25 (Mar-Apr 1970), Avail:TAC

Results are presented of an experimental investigation of heat- and mass-transfer processes in a heat pipe. The experiments were carried out at temperatures of 600 to 800°C on a heat pipe with a wick of serge webbing (the length of the pipe was 500 mm, its inside diameter 25.5 mm). It was observed by measurement of the temperature fields in the vapor space of the pipe that the particular wick used is capable of generating a very high capillary pressure (higher than 0.07 bar).

71034 EXAMINATION OF NICKEL HEAT PIPES CONTAINING POTASSIUM
DeVan, J. H.; Jansen, D. H. (Oak Ridge National Lab., Tenn.). (ORNL-TM-3077) Dec 1970. Contract W-7405-eng-26. 62p., Avail:TAC

Three heat pipes constructed of pure nickel that contained potassium as a working fluid were examined after operation at 600°C for 6000 to 10,000 hr. These heat pipes had been designed and operated by the Electronic Components Division of the Radio Corporation of America and were shipped intact to ORNL for metallurgical analyses. No deterioration of the pipes was indicated during operation, and visual examination confirmed that no serious corrosion occurred under the test conditions. Metallographic examination did reveal local areas of the evaporator in which the capillary wick and adjacent pipe wall had been attacked and the attendant formation of a black oxide scale, which appeared to be a double oxide of the type $Ni_xO_yK_z$. Metallographic examination of the condenser area revealed no metallurgical changes other than grain growth. After the test, the potassium contained 50 to 120 ppM O and less than 50 ppM metal impurities.

71035 HEAT PIPE PERFORMANCE IN AN ARTIFICIAL GRAVITY FIELD
W. C. Fackler, Collins Radio Co., Cedar Rapids, Iowa, and J. M. Trummel, University of Iowa, Iowa City, Iowa. AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

Elemental maximum energy transport formula are presented for the wick-limited heat pipe as a function of externally induced body forces. A water-screen wick heat pipe was constructed and subjected to controlled acceleration testing on a conventional laboratory centrifuge. The experimental results were compared with the predicted performance. It is shown that performance degrades stepwise starting at acceleration levels somewhat below the predicted levels.

71036 OPERATING CHARACTERISTICS AND LONG LIFE CAPABILITIES OF ORGANIC FLUID HEAT PIPES
A. Basiulis and M. Filler, Hughes Aircraft Co., Torrance, Calif. AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

A comprehensive test program on heat pipes using organic working fluids has demonstrated good performance for most cooling applications. These heat pipes have been effectively utilized to fill operating temperature gaps existing in the low and medium temperature ranges. The low thermal conductivity of the organic fluids had negligible effects on the evaporator temperature gradient between the heated surface and the saturated vapor. Additionally, life test compatibility results show very high reliability. This was further verified by a post test analysis of a 20,000-hour heat pipe which showed negligible internal mass transport, corrosion, and fluid property.

71037 EXPERIMENTAL PERFORMANCE OF GROOVED HEAT PIPES AT MODERATE TEMPERATURES
N. Kosowski and R. Kosson, Grumman Aerospace Corp., Bethpage, N.Y. AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

Heat transfer characteristics and heat transport capacity values are presented for two essentially similar grooved heat pipes. The pipes were made of 0.5 inch O.D. aluminum and had 30 internal longitudinal grooves. Tests were conducted with R-21, R-113, and ammonia working fluids, at various temperatures, charge levels, and tilt conditions. Some data also are presented with non-condensible gas added to provide variable conductance, as well as a limited amount of freezing-thawing data obtained with R-113. The grooved heat pipes are sensitive to gravity effects, but offer attractive performance coupled with a very simple and reliable construction.

71038 A VARIABLE CONDUCTANCE HEAT PIPE FLIGHT EXPERIMENT
J. P. Kirkpatrick, NASA Ames Research Center, Moffett Field, Calif., and B. D. Marcus, TRW Systems Group, Redondo Beach, Calif. AIAA 6th Thermophysics Conference, April 26-28, 1971, Avail:TAC

71045 EXPERIMENTAL HEAT PIPES
K. F. Bainton, United Kingdom Atomic Energy Authority, Harwell (England). Applied Physics Div., Jun. 1965, 14 p., ref. Submitted for Publication (AERE-M-1610), Avail: TAC

Two sodium filled heat pipes were constructed and operated successfully. The principle of their operation is discussed, the method of construction is described, and the potential of these devices is assessed.

F. SUBJECT AND AUTHOR INDEX

F.1 BIBLIOGRAPHY

00010 ABU-ROMIA M 71021 C.4-05
POSSIBLE APPLICATION OF ELECTRO-OSMOTIC FLOW PUMPING IN HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971 PAPER 71-423, AVAIL. TAC

00100 ACHENER P Y 67056 D.3-01
ALKALI METALS EVALUATION PROGRAM
AEROJET - GENERAL NUCLEONICS, SAN RAMON, CALIFORNIA.
QUART.PROG.RPT. 1 JULY 66 - 30 SEP 66, AVAIL. TAC
CONTRACT (AT (04-3)-368) (AGN-8202) 28 P.

00200 ACHENER P Y 67057 D.3-01
ALKALI METALS EVALUATION PROGRAM
AEROJET - GENERAL NUCLEONICS, SAN RAMON, CALIFORNIA NUCLEAR PRODUCTS AND SERVICES GROUP, CONTRACT (AT(04-3)-368) (AGN-8222) 30P. QUART.PROG.RPT. 1 JAN 67 - 31 MAR 67, AVAIL TAC

00300 ADT R R JR 70060 C.3-02
IRREVERSIBLE THERMODYNAMIC ANALYSIS OF THE AXIALLY HEATED HEAT PIPE
UNIV. OF MIAMI, DEPT. OF MECH. ENGRG., CORAL GABLES, FLORIDA 1969. (PAPER) AVAIL. TAC

00301 ALEACH C R 71004 B.1-05
HEAT PIPE PRINCIPLE PUT TO USE
PROFESSIONAL ENGINEER, MARCH 1971, P. 21-23 AVAIL. TAC

00400 ALLEAVITCH J 71041 C.2-04
VAPORIZATION HEAT TRANSFER FROM FLOODED WICK
DEPT. OF CHEM. ENGRG., NORTH CAROLINA STATE UNIVERSITY, RALEIGH, 1969. (PH. D. THESIS)

00500 ALLINGHAM WM D MCENTIRE J A 70056 C.2-03
DETERMINATION OF BOILING FILM COEFFICIENT FOR A HEATED HORIZONTAL TUBE IN WATER-SATURATED WICK MATERIAL
ASME J. OF HEAT TRANSFER, VOL. 83, NO. 1, FEB. 1961, PP. 71-76 AVAIL. TAC

00600 ALTIERI D PARKER J JR 71042 B.3-11
CONCEPTUAL DESIGN OF A RADIOISOTOPE HEAT-PIPE-THERMIONIC SPACE POWER SYSTEM
INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., BOULDER, COLO. AUG. 13-17, 1968.

00700 ANAND D K 66022 C.2-01
ON THE PERFORMENCE OF A HEAT PIPE
J. OF SPACECRAFT AND ROCKETS, VOL.3, NO. 5, MAY 1966, PP. 763-765. AVAIL. TAC

00800 ANAND D K 69046 B.3-07
HEAT PIPE APPLICATION TO A GRAVITY-GRADIENT SATELLITE
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19 1968, PP. 634-638. (ASME) AVAIL. TAC

00900 ANAND D K DYBBS A Z 67040 C.3-01
JENKINS R E
EFFECTS OF CONDENSER PARAMETERS ON HEAT PIPE OPTIMIZATION
J. OF SPACECRAFT AND ROCKETS, VOL. 4, NO. 5, MAY 1967, PP. 695-696. AVAIL. TAC

01000 ANAND D K HESTER R B 68017 B.3-03
HEAT PIPE APPLICATION FOR SPACECRAFT THERMAL CONTROL
TECH. MEMO OF JOHN HOPKINS APPLIED PHYSICS LAB. TG-922, AUG. 1967. AVAIL. TAC

01100 ANDEEN G B KERN F R 66023 C.4-01
GRIFFITH P
TWO-PHASE MOMENTUM FLUX AND DESIGN OF A HEAT PIPE
TID-22224 JUNE 30, 1965. AVAIL. TAC

01200 ANDERSON J L LANTZ E 69014 B.2-08
A NUCLEAR THERMIONIC SPACE POWER CONCEPT USING ROD CONTROL AND HEAT PIPES
LEWIS RESEARCH CENTER, CLEVELAND, OHIO, MAY 1969. NASA TN-D -5250. AVAIL TAC

01300 ANDERSON J L LANTZ E 68012 B.2-07
THERMIONIC HEAT PIPE SPACE POWER CONCEPT
TRANS. AMER. NUCL. SOC., 11 14 (JUNE 1968) AVAIL. TAC

01400 ARCELLA F G DZAKOWIC G S 69003 A-03
HEAT PIPES FUNCTION ISOTHERMALLY AND ADAPTABLY
SPACE AND AERONAUTICS, AUG, 1969, PP. 58-60. AVAIL. TAC

01500 ARMAND M SHROFF A M 69061 C.1-03
PRELIMINARY RESULTS OF A STUDY OF HEAT PIPES AT HIGH TEMPERATURE
PROCEEDINGS SECOND INTERN'L. CONF. ON THERMIONIC ELECTRICAL POWER GENERATION (A69-29172 14-03), MAY 1968, PP. 557-563.

EUR 4210. AVAIL. TAC

01600 BAEHR A BURCK E 69072 C.4-02
HUFSCHMIDT W
LIQUID-VAPOR INTERACTION AND EVAPORATION IN HEAT PIPES
PROC. 2ND INT'L CONF. ON THERMIONIC ELECTRICAL POWER
GENERATION MAY27-31, 1968. STRESA, ITALY EUR 4210 F, E P.
543-556. AVAIL. TAC

01700 BAINES W D PETERSON E G 50001 C.4-01
INVESTIGATION OF FLOW THROUGH SCREENS
ASME TRANSACTIONS, 1950, PP. 467-80. AVAIL. TAC

01800 BAINTON K F 71045 E-11
EXPERIMENTAL HEAT PIPES
UNITED KINGDOM ATOMIC ENERGY AUTHORITY MEMO AERE-M1610,
HARWELL, ENGLAND, 1965. AVAIL. TAC

01900 BARNETT C S 67018 B.2-05
AN OUT-OF-PILE HEAT PIPE THERMIONIC SPACE-POWER CONCEPT
TRANS. AMERICAN NUCLEAR SOCIETY, VOL. 9, NO. 2, NOV. 1966,
PP. 338-339. AVAIL. TAC

01901 BARSCH W O SCHOENHALS R J 71001 A-04
WINTER E R F VISKANTA R
THE STUDY AND CLASSIFICATION OF TWO AND MULTI-COMPONENT HIGH
THERMAL CONDUCTANCE DEVICES
INTERIM REPORT, AUG. 20, 1970, CONTRACT NAS8-24015, NASA-CR-
102943, 263 P., AVAIL. TAC

02000 BASIULIS A DIXON J C 69054 B.5-01
AN ELECTRICALLY INSULATED HEAT PIPE FOR DEPRESSED COLLECTORS
CONF. ON TUBE TECHNIQUES, 9TH, NEW YORK, SEPT. 17-18, 1968,
PP. 176-181, AVAIL. TAC

02100 BASIULIS A DIXON J C 69058 B.5-02
HEAT PIPE DESIGN FOR ELECTRON TUBE COOLING
ASME AND AICHE HEAT TRANSFER CONF., MINNEAPOLIS, MINN., AUG.
3-6, 1969. (ASME PAPER NO. 69-HT-25) AVAIL. TAC

02200 BASIULIS A 70030 B.3-09
UNIDIRECTIONAL HEAT PIPES TO CONTROL TWT TEMPERATURE IN
SYNCHRONOUS ORBIT
THERMODYNAMICS AND THERMOPHYSICS OF SPACE FLIGHT
PROCEEDINGS OF SYMPOSIUM, PALO ALTO, CALIF., MARCH 23-25,

1970, P 165-173, CONT.NO. NAS-3-9719, AVAIL. TAC

02201 BASIULIS A FILLER M 71036 E-10
OPERATING CHARACTERISTICS AND LONG LIFE CAPABILITIES OF ORGANIC FLUID HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-408, AVAIL. TAC

02300 BASIULIS A STARR M C 68008 B.1-03
IMPROVED RELIABILITY OF TRAVELING-WAVE TUBES THROUGH THE USE OF A NEW LIGHT-WEIGHT REMOVAL DEVICE
IEEE TRANS. ELECTRON DEVICES, AUG, 1968, AVAIL TAC
1967. AVAIL. TAC

02400 BIENERT W B LEVEDAHL W J 69052 B.4-02
STREB A J
THERMAL CONTROL AND POWER FLATTENING FOR RADIOISOTOPIC THERMODYNAMIC POWER SYSTEM
(TO MARTIN-MARIETTA CO.) BRITISH PATENT 1,160,568. AUG. 6, 1969. FILED NOV. 21, 1966.

02500 BIENERT W B FRANK S 68011 B.2-07
HANNAH R PETERS J T
APPLICATION OF HEAT PIPES TO SNAP-29
IECEC 68 INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., UNIV. OF COLO., BOULDER, COLO., AUG. 13-17, 1968, PP. 477-486. AVAIL. TAC

02501 BIENERT W B BRENNAN P J 71027 D.1-08
KIRKPATRICK J P
FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-421, AVAIL. TAC

02600 BIENERT W 69010 B.1-04
HEAT PIPES FOR TEMPERATURE CONTROL
PROC. OF 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., WASHINGTON, D.C. SEPT. 22-26, 1969 (PAPER NO. 699128) PP. 1033-1041. AVAIL TAC

02601 BILENAS J A HARWELL W 70069 D.1-06
ORBITAL ASTRONOMICAL OBSERVATORY HEAT PIPE - DESIGN ANALYSIS TESTING
ASME PAPER 70-HT/SPT-9 AVAIL. TAC (9P.)

02700 BLISS F E JR CLARK E G JR 70086 E-08
STEIN B
CONSTRUCTION AND TEST OF A FLEXIBLE HEAT PIPE
SANDERS ASSOCIATES, INC., ASME PAPER 70-HT/SPT-13 AVAIL. TAC

02800 BOHDANSKY J 69027 B.2-12
POWER FROM THERMIONIC CONVERTERS
ATOMWIRTSCHAFT, VOL. 13, NOV. 1968, PP. 548-549. (IN GERMAN)
AVAIL. TAC

02801 BOHDANSKY J 71009 B.2-15
HEAT FLOW MEASUREMENTS IN A THERMIONIC CONVERTER
IEEE THERMIONIC CONVERSION SPECIALIST CONF., CARMEL, CAL.
OCT. 21-23, 1969, CONF. RECORD P. 517-520. AVAIL. TAC

02900 BOHDANSKY J SCHINS H E J 67012 B.1-02
THE SURFACE TENSION OF THE ALKALI METALS
J INORG. NUCL. CHEM. 1967 VOL. 29 (2173-79) AVAIL. TAC

03000 BOHDANSKY J SCHINS H E J 65005 B.1-01
NEW METHOD FOR VAPOR-PRESSURE MEASUREMENTS AT HIGH
TEMPERATURE AND HIGH PRESSURE
J. OF APPL. PHYSICS VOL. 36, NO. 11 (3683-4) NOV. 1965.
AVAIL. TAC

03100 BOHDANSKY J SCHINS H E J 67011 B.1-02
THE VAPOR PRESSURE OF YTTERBIUM IN THE PRESSURE RANGE OF 40
TO 400 TORR
J. LESS-COMMON METALS 1967, VOL. 13 (248) AVAIL. TAC

03200 BOHDANSKY J SCHINS H E J 67010 B.1-02
VAPOR PRESSURE OF DIFFERENT METALS IN THE PRESSURE RANGE OF
50 TO 4000 TORR
J. OF PHYSICAL CHEMISTRY 1967, VOL. 71 (215-17) AVAIL. TAC

03300 BOHDANSKY J SCHINS H E J 67009 B.1-02
SURFACE TENSION AND DENSITY OF THE LIQUID EARTH ALKALINE
METALS MG, CA, SR, BA
J. INORG. NUCL. CHEM. 1968, VOL. 30 (2331-37) AVAIL. TAC

03400 BOHDANSKY J SCHINS H E J 68007 B.1-03
THE SURFACE TENSION OF AG, TL, PB, AND BI AT HIGH
TEMPERATURE
J. INORG. NUCL. CHEM. 1968, VOL. 30 (3362-65) AVAIL. TAC

03500 BOHDANSKY J SALAMON K 67023 B.2-06
VAN ANDEL E
INTEGRATED CS-GRAPHITE RESERVOIR SYSTEM IN A HEAT PIPE THERMIONIC CONVERTER
DIRECT CONVERSION GROUP, EURATOM CCR, ISPRA, ITALY.
THERMIONIC CONVERSION SPECIALISTS CONF. PALO ALTO, CALIF. OCT. 1967, P. 93-96, 8 REF. AVAIL. TAC

03600 BOHDANSKY J SCHINS H E J 66015 B.3-01
HEAT TRANSFER OF A HEAT PIPE OPERATING AT EMITTER TEMPERATURE
FIRST INTERN'L. CONF. ON THERMIONIC ELEC. POWER GENERATION, ISPRA, ITALY, SEPT. 20-29, 1965. AVAIL TAC

03700 BOHDANSKY J BUSSE C A 68020 B.4-01
GROVER G M
COOLING SYSTEM FOR NUCLEAR REACTORS
CANADIAN PATENT 765, 919, AUG. 22. 1967.

03800 BOHDANSKY J STRUB H 68027 C.2-01
VAN ANDEL E
HEAT TRANSFER MEASUREMENTS USING A SODIUM HEAT PIPE WORKING AT LOW VAPOR PRESSURE
IEEE CONF. RECORD OF THE 1966 THERMIONIC CONVERSION CONVERSION SPECIALISTS CONF., HOUSTON, TEXAS, NOV. 3-4, 1966, PP. 144-148. AVAIL. TAC

03900 BOHDANSKY J VAN ANDEL E 69024 B.2-11
CALORIMETRIC MEASUREMENTS WITH A HEAT PIPE THERMIONIC CONVERTER
INTERN'L CONF. ON THERMIONIC ELEC. POWER GENERATION (A69-29172 14-03) 1968, PP. 989-996. AVAIL. TAC

04000 BOHDANSKY J VAN ANDEL E 68014 B.2-08
HEAT PIPE THERMIONIC CONVERTER WITH GRAPHITE ABSORPTION CESIUM RESERVOIR WORKING AT COLLECTOR TEMPERATURE
IEEE CONF. RECORDINGS OF THE 1966 THERMIONIC CONVERSION SPECIALISTS CONF., HOUSTON, TEXAS, NOV.3-4, 1966, PP. 239-242. AVAIL. TAC

04001 BREITWIESER R LANTZ E 70011 B.2-12
A DESIGN STUDY OF A 350 KWE OUT-OF-CORE NUCLEAR THERMIONIC CONVERTER SYSTEM
NASA LEWIS RES. CNTR., CLEVELAND, OHIO (NASA-TM-X-52846), AVAIL. TAC

04004 BREITWIESER R — 71005 B.2-14
USE OF HEAT PIPES FOR ELECTRICAL ISOLATION
IEEE THERMIONIC CONVERSION SPECIALIST CONF., MIAMI, FLA.
26-29 OCT., 1970 (NASA-TM-X-52928, E-6059) 8 P., AVAIL. TAC

04010 BRENNAN P J — 71024 D.1-07
STUDY TO EVALUATE THE FEASIBILITY OF A FEEDBACK CONTROLLED
VARIABLE CONDUCTANCE HEAT PIPE
CONTRACT NAS2-5722, NASA-CR-73475, DTM-70-4, SEPT. 1970, 69P
AVAIL TAC

04100 BRESSLER R G WYATT P W — 70059 C.3-02
SURFACE WETTING THROUGH CAPILLARY GROOVES
AICHE PREPRINT 19, ASME-AICHE HEAT TRANSFER CONF.,
MINNEAPOLIS, MINN., AUG. 3-6, 1969. AVAIL. TAC

04200 BROSENS P — 68044 E-03
HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT
THERMO ELECTRON ENGRG. CORP., WALTHAM, MASS., DEC. 1967.
NASA-CR 93664. AVAIL TAC

04300 BROSENS P — 67017 B.2-05
THERMIONIC CONVERTERS WITH HEAT-PIPE RADIATORS
ASME INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., MIAMI
BEACH, FLA., AUG. 13-17, 1967, PP. 181-187. AVAIL TAC

04400 BROSENS P — 67022 B.2-06
ADVANCED CONVERTER DEVELOPMENT
THERMO ELECTRON CORPORATION, WALTHAM, MASS., THERMIONIC
CONVERSION SPECIALIST CONF., PALO ALTO, CALIF. OCT. 1967,
P. 68-73, 7 REF. AVAIL. TAC

04401 BURGES R T — 68053 E-04
DESIGN AND OPERATION OF A HEAT PIPE
MASTER'S THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF.
(44P.), AVAIL. TAC

04500 BUSSE C A — 70053 C.2-03
THEORY OF THE SONIC HEAT TRANSFER LIMIT OF HEAT PIPES
EURATOM CCR, 21020 ISPRA, ITALY (17P) AVAIL. TAC

04600 BUSSE C A — 70079 D.3-03
CORROSION IN HIGH TEMPERATURE LITHIUM HEAT PIPES WITH
NIOBIUM-1ZIRCONIUM OR TANTALUM AS WALL MATERIAL
EUR 4298. (CORROSION SCIENCE 10, 65-84 (1970)) (IN GERMAN &

TRANSL.) AVAIL. TAC

04700 BUSSE C A 69060 C.1-03
HEAT PIPE RESEARCH IN EUROPE
SECOND INTERN'L. CONF. ON THERMIONIC ELEC. POWER GENERATION
STRESA, PROCEEDINGS A69-29172 14-03, ITALY, MAY 27-31, 1968.
AVAIL. TAC

04800 BUSSE C A 69025 B.2-11
HEAT PIPE THERMIONIC CONVERTER RESEARCH IN EUROPE
PROC. OF THE 4TH INTERSOCIETY ENERGY (AICHE) CONVERSION
ENGRG. CONF., WASHINGTON, D.C., SEPT. 22-26, 1969, PP.861-
872. AVAIL. TAC

04900 BUSSE C A 66003 B.2-02
OPTIMIZATION OF HEAT PIPE THERMIONIC CONVERTERS FOR SPACE
POWER SUPPLIES
EUR 2534.E , 1965. AVAIL. TAC

05000 BUSSE C A 67042 C.4-02
PRESSURE DROP IN THE VAPOR PHASE OF LONG HEAT PIPES
IEEE CONF. RECORD OF THE 1967 THERMIONIC CONVERSION
SPECIALIST CONF., PALO ALTO, CALIF., OCT. 30-NOV. 1, 1967,
PP. 391-399. AVAIL. TAC

05100 BUSSE C A CARON R 65011 B.2-02
CAPPELLETTI C
PROTOTYPES OF HEAT PIPE THERMIONIC CONVERTERS FOR SPACE
REACTORS
FIRST INTERN'L. CONF. ON THERMIONIC ELECTRICAL POWER GENER.
LONDON, ENGLAND, SEPT. 20-24, 1965. AVAIL TAC

05200 BUSSE C A CARON R 66027 D.1-01
GEIGER F POETZSCHKE M
PERFORMANCE STUDIES ON HEAT PIPES
FIRST INTER'L. CONF. ON THERMIONIC ELEC. POWER GENERATION,
LONDON ENGLAND, SEPT. 20-25, 1965. AVAIL. TAC

05300 BUSSE C A GEIGER F 69092 D.3-01
STRUB H POETZSCHKE M
KRAFT G
HIGH TEMPERATURE LITHIUM HEAT PIPES
INTERN'L. CONF. ON THERMIONIC ELEC. POWER GENERATION, PROC.
(A69-29172 14-03) ITALY, MAY 27-31, 1968, PP. 495-506.
AVAIL. TAC

05400 BUSSE C A GEIGER F 68055 E-05
QUATAERT D POETZSCHKE M
HEAT PIPE LIFE TESTS AT 1600 DEGREES C AND 1000 DEGREES C
IEEE CONF. RECORD OF THE 1966 THERMIONIC CONVERSION
SPECIALIST CONF., HOUSTON, TEXAS, NOV. 3-4, 1966, PP. 149-
158. AVAIL. TAC

05401 BYRD A W 71008 B.2-14
HEAT PIPE THERMIONIC DIODE POWER SYSTEM
US PATENT 3509386, 28 APRIL 1970, JP (NASA - CASE - XMF -
05843) AVAIL. TAC

05500 CALIMBAS A T HULETT R H 69043 B.3-07
AN AVIONIC HEAT PIPE
ASME PAPER 69-HT-16, PROC. OF THE 4TH INTERSOCIETY ENERGY
CONVERSION ENGRG. CONF., WASHINGTON, D.C., SEPT. 22-26,
1969, PP. 1010-1015. AVAIL. TAC

05600 CALIMBAS A T HULETT R H 69042 B.3-06
AVIONIC APPLICATION OF A HEAT PIPE
PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF.
WASHINGTON, D.C., SEPT. 22-26, PP. 1016-1024. AVAIL. TAC

05700 CAMPANA R J HOLLAND J W 64003 D.1-01
STATUS REPORT ON HEAT PIPES
GULF GENERAL ATOMIC, INC., GA-5676, SEPT. 17, 1964. AVAIL.
TAC

05800 CARLSON G 67047 D.1-02
HEAT PIPE RADIATOR DESIGN
LAWRENCE RAD. LAB., LIVERMORE, CALIF., SPACE POWER NOTE NO.
214, JUNE 15, 1967. AVAIL. TAC

05801 CARLSON G A HOFFMAN M A 70045 C.1-05
EFFECT OF MAGNETIC FIELDS ON HEAT PIPES
PROC. ASME SPACE TECH. HEAT TRANSFER CONF., LOS ANGELES,
JUNE 21-24, 1970 (PART 2) (11 P.) ASME PAPER 70HT/SPT-10,
AVAIL. TAC

05900 CARNESALE A COSGROVE J H 67035 C.1-02
FERRELL J K
OPERATING LIMITS OF THE HEAT PIPE
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB HEAT
PIPE CONF., VOL. 1, OCT. 1966, SC-M-66-623. AVAIL. TAC

05901 CASAZZA S A JOACHIM R J 70039 B.5-02
A SURVEY OF COOLING TECHNIQUES FOR AIRCRAFT ELECTRONIC EQUIPMENT
IEEE EASTERN ELECTRONICS PACKAGING CONFERENCE, MASS. INST. TECH., CAMBRIDGE, MASS. JUNE 8-9, 1970 PROCEEDINGS (P. 5.2.1 -5.2.14), AVAIL. TAC

06000 CHATO J C STRECKERT J H 69089 D.2-04
PERFORMANCE OF A WICK-LIMITED HEAT PIPE
ASME 69-HT-20, 1969, AVAIL. TAC

06100 CHERKASSKII A KH 70036 B.4-03
INDEPENDENT HEAT PIPES
AKADEMUYA NAUK, IZVESTIYA, ENERGETIKA I TRANSPORT, NO. 3, MAY-JUNE 1969, PP. 95-103. (IN RUSSIAN)

06200 CHEUNG H 67048 D.1-02
HEAT PIPE OPTIMIZATION
LAWRENCE RAD. LAB., U. OF CAL., LIVERMORE, UCID-15531, SPACE POWER NOTE NO. 264, DEC. 19, 1967, AVAIL. TAC

06300 CHEUNG H 68002 A-02
A CRITICAL REVIEW OF HEAT PIPE THEORY AND APPLICATIONS
UNIV. OF CALIF., LAWRENCE RAD. LAB., UCRL-50453, JULY 15, 1968, AVAIL. TAC

06301 CHI S W 71019 C.1-06
MATHEMATICAL MODELING OF CRYOGENIC HEAT PIPES
(GRANT NGR-09-005-071), NASA-CR-116175, SEPT. 1970, 123 P. AVAIL. TAC

06400 CHI S W CYGNAROWICZ T A 70071 D.1-07
THEORETICAL ANALYSIS OF CRYOGENIC HEAT PIPES
ASME PAPER 70-HT/SPT-6 AVAIL. TAC

06401 COLWELL G T WILLIAMS C L 71020 C.4-05
HSU J C ZEVALLOS G E
A STUDY OF NONCONDENSIBLE EFFECTS IN A HEAT PIPE
NUCLEAR TECHNOLOGY, VOL. 10, MARCH 1971 P. 293-300, AVAIL. TAC

06410 CLAUSEN O W MARCUS B D 71023 D.1-07
PISKE W E TURNER R C
CIRCUMFERENTIAL HEAT PIPE SYSTEMS FOR LARGE STRUCTURES
CONTRACT NAS9-10299, NASA-CR-114783 DEC. 1970, 177 P.

AVAIL. TAC

06500 CONWAY E C KELLEY M J 69056 B.5-01
WILMARTH R W BEGGS J E
NONELECTRIC CATHODE HEATING
INST. OF ELECTRICAL AND ELECTRONICS ENGINEERS. CONF. ON
TUBE TECHNIQUES, 9TH, NEW YORK, NEW YORK, SEPT. 17, 18, 1968
CONFERENCE RECORD, P. 191-195. AVAIL. TAC

06600 CONWAY E C WILMARTH R W 69055 B.5-01
COOLING OF A HIGH POWER ELECTRON TUBE IN A SPACE VEHICLE
IN IEEE CONF. ON TUBE TECH., 9TH N. Y., SEPT. 17, 18, 1968.
CONTRACT NAS12565, AVAIL. TAC

06700 CONWAY E C KELLEY M J 68036 D.1-03
A CONTINUOUS HEAT PIPE FOR SPACECRAFT THERMAL CONTROL
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE
16-19, 1968, PP. 655-658. (G.E.), AVAIL. TAC

06800 COSGROVE J H 68035 D.1-03
ENGINEERING DESIGN OF THE HEAT PIPE
NORTH CAROLINA STATE UNIV., RALEIGH, 1967. (PH. D. THESIS)

06900 COSGROVE J H FERRELL J K 67038 C.1-02
CARNESALE A
OPERATING CHARACTERISTICS OF CAPILLARY-LIMITED HEAT PIPES
JOURNAL OF NUCLEAR ENGERGY, JULY 1967, VOL.21,NO.7 (547-558)
AVAIL. TAC

07000 COSTELLO C P FREA W J 64002 C.2-01
THE ROLES OF CAPILLARY WICKING AND SURFACE DEPOSITS IN THE
ATTAINMENT OF HIGH POOL BOILING BURNOUT HEAT FLUXES
UNIV. OF WASHINGTON, SEATTLE, WASH. A.I.CH.E. JOURNAL, VOL.
10, NO. 3, P. 393-8. (MAY 1964) AVAIL TAC

07100 COSTELLO C P REDEKER E R 63001 C.2-01
BOILING HEAT TRANSFER AND MAXIMUM HEAT FLUX FOR A SURFACE
WITH COOLANT SUPPLIED BY CAPILLARY WICKING
CHEMICAL ENGINEERING PROGRESS SERIES, VOL. 41, 1963, P. 104-
113. AVAIL. TAC

07200 COTTER T P 68046 E-03
HEAT PIPE STARTUP DYNAMICS
IEEE CONF. RECORD OF THE 1967 THERMIONIC CONVERSION
SPECIALIST CONF., PALO ALTO, CALIF., OCT. 30 - NOV. 1, 1967.

AVAIL. TAC

07300 COTTER T P 67034 C.1-02
STATUS OF THE ENGINEERING THEORY OF HEAT PIPES
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB HEAT PIPE CONF., VOL. 1, OCT. 1966. AVAIL. TAC

07400 COTTER T P 65001 A-01
THEORY OF HEAT PIPES
LOS ALAMOS SCI. LAB., LA-3246-MS, TID-4500 (37TH ED.), FEB. 23, 1965. AVAIL. TAC

07500 COTTER T P DEVERALL J 66031 E-01
ERICKSON G F GROVER G M
KEDDY E S KEMME J E
SALMI E W
STATUS REPORT ON THEORY AND EXPERIMENTS ON HEAT PIPES AT LOS ALAMOS
LOS ALAMOS SCI. LAB. REPORT LADC-7206, 1965. AVAIL. TAC

07501 SHELPUK B CROUTHAMEL T A 70010 B.1-05
CYGNAROWICZ T A
ICICLE - INTEGRATED CRYOGENIC ISOTOPE COOLING ENGINE SYSTEM
ASME PAPER 70-HT/SPT-30, AVAIL. TAC

07600 CYGNAROWICZ T A MALONEY J A 70009 B.1-05
WRIGHT P E
INTEGRATED CRYOGENIC ISOTOPE COOLING ENGINE SYSTEM - ICICLE FEASIBILITY STUDY
FINAL REPORT, ADVANCED TECHN. LABS. DEFENSE ELECTRONIC PRODUCTS, CAMDEN, N.J. 08102 (CONTRACT NO NAS5-21039)
AVAIL. TAC

07700 DAGBJARTSSON S GROLL M 69019 B.2-10
SCHLOERB O PRUSCHEK R
AN IMPROVED OUT-OF-CORE THERMIONIC REACTOR FOR LOW POWER
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL THERMIONIC CONVERSION SPECIALIST CONFERENCE, 7TH, FRAMINGHAM, MASSACHUSETTS OCTOBER 21-23, 1968, CONFERENCE RECORD. (A69-21806 09-03), NEW YORK, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC., 1968, P. 299-304. AVAIL. TAC

07701 DAILEY C C 71016 B.5-03
MICROWAVE POWER RECEIVING ANTENNA
US PATENT 3535543, 20 OCT. 1970 (NASA - CASE - MFS - 20333) 7P. AVAIL. TAC

07800 DALLAS D B 68003 A-02
THE HEAT PIPE
ASTME STUDENT QUARTERLY FALL 1968. AVAIL. TAC

07900 DAY W R LUCHSINGER T H 69030 B.3-04
ANALYTICAL STUDY PROGRAM TO DEVELOP THE THEORETICAL DESIGN OF SPACE BORN ELECTROSTATICALLY FOCUSSED KLYSTRON AMPLIFIERS
LITTON INDUSTRIES SAN CARLOS, CALIFORNIA, ELECTRON TUBE DIV. CONTRACT NAS3-11515 (NASA-CR-72449), AVAIL. TAC

07901 DALEY T J 70085 E-08
THE EXPERIMENTAL DESIGN AND OPERATION OF A ROTATING WICKLESS HEAT PIPE
MASTER'S THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF. JUNE 1970, (60P.), AVAIL. TAC

08000 DE TROYER A NEVE DE MEVERGNIES E 69022 B.2-10
BRABERS M J DEJONGHE P
GAMMEL G GROSS F
KOSKINEN M F LANGPAPE R
DESIGN AND CHARACTERISTICS OF AN ACTINIUM FUELED THERMIONIC GENERATOR
INTERNATIONAL CONFERENCE OF THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS EUR NO. 4210 F.E 1969, P.305-306, 9 REFS, AVAIL TAC

08001 DEVAN J H JANSEN D H 71034 E-10
EXAMINATION OF NICKEL HEAT PIPES CONTAINING POTASSIUM
CONTRACT W-7405-ENG-26, ORNL-TM-3077, DEC 1970, 62 P. AVAIL. TAC

08100 DEVERALL J E 68005 B.1-02
TOTAL HEMISPHERICAL EMISSIVITY MEASUREMENTS BY HEAT PIPE METHOD
ANNUAL AVIATION AND SPACE CONFERENCE, BEVERLY HILLS, CALIFORNIA JUNE 16-19, 1968, PP. 649-654. (ALSO LA-3834-MS) AVAIL. TAC

08200 DEVERALL J E 68043 E-02
THE EFFECT OF VIBRATION ON HEAT PIPE PERFORMANCE
LOS ALAMOS SCIENTIFIC LAB, LA-3798 OCT. 4, 1967. AVAIL. TAC

08300 DEVERALL J E KEMME J E 65015 E-01
HIGH THERMAL CONDUCTANCE DEVICES UTILIZING THE BOILING OF LITHIUM OR SILVER

LOS ALAMOS SCIENTIFIC LAB REPORT, LA-3211, OCT. 1964, AVAIL.
TAC

08400 DEVERALL J E 70076 D.3-02
MERCURY AS A HEAT PIPE FLUID
LOS ALAMOS SCIENTIFIC LAB REPORT, LA-4300-MS, JAN. 1970.
(ALSO ASME PAPER 70-HT/SPT-8) AVAIL. TAC

08500 DEVERALL J E KEMME J E 65012 B.3-01
SATELLITE HEAT PIPE
LOS ALAMOS SCIENTIFIC LAB REPORT, LA-3278-MS, TID-4500 (39TH
ED.), JAN. 1965. AVAIL. TAC

08501 DEVERALL J E KEMME J E 71032 E-10
FLORSCHUETZ L W
SONIC LIMITATIONS AND STARTUP PROBLEMS OF HEAT PIPES
CONTRACT W-7405-ENG-36, LA-4518, SEPT. 1970, 25 P. AVAIL.
TAC

08600 DEVERALL J E SALMI E W 68045 E-03
HEAT PIPE PERFORMANCE IN A SPACE ENVIRONMENT
IEEE CONFERENCE RECORD OF THE 1967 THERMIONIC CONVERSION
SPECIALIST CONFERENCE, PALO ALTO, CALIFORNIA, OCT. 30-NOV.
1, 1967, PP. 359-362. (LA-DC-9028) AVAIL TAC

08700 DEVERALL J E SALMI E W 68050 E-04
KNAPP R J
HEAT PIPE PERFORMANCE IN A ZERO-G GRAVITY FIELD
J. SPACECRAFT AND ROCKETS, VOL. 4, NO. 11, NOV. 1967, P.
1556-1557. AVAIL. TAC

08800 DEVERALL J E SALMI E W 67030 B.3-02
KNAPP R J
ORBITAL HEAT PIPE EXPERIMENT
LOS ALAMOS SCIENTIFIC LAB REPORT, LA-3714, JUNE 5, 1967
AVAIL. TAC

08900 DORNER S REISS F 67055 D.2-02
SCHRETZMANN K
EXPERIMENTAL INVESTIGATIONS ON SODIUM FILLED HEAT PIPES
INSTITUT FUER NEUTRONENPHYSIK UND REAKTORTECHNIK,
KERNFORSCHNUGSZENTRUM KARLSRUHE, GERMANY JAN. 1967 (IN
GERMAN), AVAIL. TAC

09000 DUTCHER C H BURKE M R 69059 B.5-02

APPLICATIONS OF HEAT PIPES IN ELECTRONIC EQUIPMENT
ELECTRONIC COMMUNICATIONS, INC. DEPT. NO. AER-69-0011 AVAIL.
TAC

09100 DUTCHER C H JR BURKE M R 70038 B.5-02
HEAT PIPES - A COOL WAY TO COOL CIRCUITRY
ELECTRONIC COMMUNICATIONS INC., ST. PETERSBURG, FLORIDA.
ELECTRONICS VOL. 43, FEB. 15, 1970 P. 94-100. AVAIL. TAC

09200 DZAKOWIC G S TANG Y S 69075 C.4-03
ARCELLA F G
EXPERIMENTAL STUDY OF VAPOR VELOCITY LIMIT IN A SODIUM HEAT
PIPE
ASME 69-HT-21. AVAIL. TAC

09300 EASTMAN G Y 69004 A-03
THE HEAT PIPE - A PROGRESS REPORT
PROC. 4TH INTERSOC. ENERGY CONV. ENGRG. CONF. WASHINGTON,
D.C. SEPT 22-26,1969 (873-878) AVAIL TAC

09400 EASTMAN G Y 68001 A-02
THE HEAT PIPE
SCI. AMERICAN, VOL. 218, MAY 1968, PP. 38-46. AVAIL. TAC

09500 EASTMAN G Y ERNST D M 67015 B.2-04
HALL W B
REVIEW OF FOSSIL-FUEL-FIRED THERMIONIC ENERGY CONVERTERS
IEEE THERMIONIC CONVERSION SPECIALIST CONFERENCE, HOUSTON,
TEXAS 1966. AVAIL. TAC

09600 EASTMAN G Y 70005 A-04
HEAT PIPE - SPACE SPINOFF FOR HEAT TRANSFER
SPEC POWER DEVICES ENGG. R.C.A. LANCASTER, PENNSYLVANIA.
HEATING, PIPING AIR COND. 1969 41 (12) 57-61 (ENG.) AVAIL.
TAC

09700 EBY R J GOLDBERG G I 70027 B.3-09
A MILLIMETER WAVE PARABOLIC ANTENNA FOR COMMUNICATIONS WITH
A SYNCHRONOUS SATELLITE
FAIRCHILD HILLER CORP.,SPACE AND ELECTRONICS SYSTEMS DIV.,
GERMANTOWN, MARYLAND, AEROSPACE STRUCTURES DESIGN CONFERENCE
SEATTLE, WASHINGTON, AUG. 4, 5, 1969 PROCEEDINGS SEATTLE,
WASHINGTON, SEATTLE PROFESSIONAL ENGINEERING EMPLOYEES
ASSOCIATION 1969 P. 2-1 TO 2-13. AVAIL. TAC

09701 EGGERS P E SERKIZ A W 71025 D.1-07
DEVELOPMENT OF CRYOGENIC HEAT PIPES
ASME WINTER ANNUAL MEETING, NEW YORK, N.Y., NOV. 29-DEC. 3, 1970, PAPER 70-WA/ENER-1, 8 P., AVAIL TAC

09710 EDELSTEIN F HEMBACH R J 71028 D.1-08
THE DESIGN, FABRICATION, AND TESTING OF A VARIABLE CONDUCTANCE HEAT PIPE FOR EQUIPMENT THERMAL CONTROL
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-422, AVAIL. TAC

09800 ERNST D M 67037 C.1-02
EVALUATION OF THEORETICAL HEAT PIPE PERFORMANCE
THERMO ELECTRON CORP., WALTHAM, MASSACHUSETTS, 6TH THERMIONIC CONVERSION SPECIALISTS CONFERENCE, PALO ALTO, CALIFORNIA, OCT. 1967 6P., 6 REFS. AVAIL. TAC

09900 ERNST D M EASTMAN G Y 68006 B.1-03
TWO PIECE HEAT PIPE CONVERTER
21ST ANNUAL POWER SOURCES CONFERENCE-PROC., U.S. ARMY ELECTRONICS LABORATORIES, FORT MONMOUTH, NJ MAY 16-18 1967 P. 135-38. AVAIL. TAC

09901 ERNST D M LEVY E K 69018 B.2-09
SHEFSIEK P K
HEAT PIPE STUDIES AT THERMO ELECTRON CORPORATION
IEEE CONF. RECORD OF THE 1968 THERMIONIC CONVERSION SPECIALIST CONF. (7TH CONF.), FRAMINGHAM, MASSACHUSETTS, OCT. 21-23, 1968, PP. 254-257. AVAIL. TAC

09902 EWALD R LACAZE A 70064 C.4-05
PERROUD P
FLOODING PHENOMENON IN A CRYOGENIC HEAT PIPE WITH VERTICAL COUNTERCURRENT TWO-PHASE FLOW
CONF-700522-1. (14P.) (IN FRENCH), AVAIL. TAC

09903 EWERS B J 70012 B.2-12
A PARAMETRIC ANALYSIS OF A DEEP SEA RADIOISOTOPIC THERMOELECTRIC GENERATOR EMPLOYING A HEAT PIPE
M.S. THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF. (AD-704790) (69 P.), AVAIL. TAC

09910 EWALD R PERROUD P 71031 E-10
MEASUREMENTS OF FILM CONDENSATION HEAT TRANSFER COEFFICIENTS IN VERTICAL TUBES FOR NITROGEN, HYDROGEN AND DEUTERIUM
CRYOGENIC ENGINEERING CONFERENCE, BOULDER, COLO. (CONF-700

628-1) 21 P., AVAIL. TAC

09920 FACKLER W C TRUMMEL J M 71035 E-10
HEAT PIPE PERFORMANCE IN AN ARTIFICIAL GRAVITY FIELD
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971 PAPER 71-
419, AVAIL TAC

10000 FARRAN R A STARNER K E 69086 D.2-03
DETERMINATION OF WICKING PROPERTIES OF COMPRESSIBLE
MATERIALS FOR HEAT PIPE APPLICATIONS
AIR FORCE REPORT NO. SAMSO-TR-68-428, JULY 1968, AVAIL TAC

10100 FARRAN R A STARNER K E 68039 D.2-03
DETERMINING WICKING PROPERTIES OF COMPRESSIBLE
MATERIALS FOR HEAT PIPE APPLICATIONS
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE
16-19, 1968, PP. 659-669. AVAIL. TAC

10200 FELDMAN K T JR 70068 D.1-06
ANALYSIS AND DESIGN OF HEAT PIPES
UCLA EXTENSION COURSE NOTES 868.4, LOS ANGELES, CALIF., JUNE
23-27, 1969, AND JUNE 22-26, 1970. AVAIL. TAC

10300 FELDMAN K T JR WHITING G H 70001 A-04
APPLICABILITY OF HEAT PIPES TO ENERGY CONVERSION SYSTEMS
SANDIA CORPORATION, AEROSPACE RADIOISOTOPE POWER, REPORT
NO. SC-ARPIC-1012, JUNE 1969. AVAIL. TAC

10400 FELDMAN K T 68038 D.1-04
WORKSHOP ON HEAT PIPE DESIGN AND ANALYSIS
UNIV. OF NEW MEXICO, APRIL 1968. AVAIL. TAC

10500 FELDMAN K T WHITING G H 69001 A-02
APPLICATIONS OF THE HEAT PIPE
MECHANICAL ENGINEERING ASME, VOL. 90, NOV. 1968, PP. 48-53.
AVAIL. TAC

10600 FELDMAN K T WHITLOW G L 69096 E-06
EXPERIMENTS WITH A TWO-FLUID HEAT PIPE
PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF.
WASHINGTON, D. C., PAPER NO. 699127, SEPT. 22-26, 1969, PP.
1025-1032. AVAIL. TAC

10700 FELDMAN K T WHITING G H 67006 A-02

THE HEAT PIPE
MECHANICAL ENGINEERING (ASME) , FEB. 1967, PP. 30-33. AVAIL.
TAC

10800 FERRELL J K JOHNSON H R 70061 C.3-03
THE MECHANISM OF HEAT TRANSFER IN THE EVAPORATOR ZONE OF A
HEAT PIPE
ASME PAPER 70-HT/SPT-12 AVAIL. TAC

10900 FERRELL J K 69065 C.1-04
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
U.S. ATOMIC ENERGY COM. CONTRACT AT-(40-1)-3411, NORTH
CAROLINA STATE UNIVERSITY, APRIL 1969. (PART 1&2), AVAIL.
TAC

11000 FERRELL J K ALLEAVITCH J 69070 C.3-02
VAPORIZATION HEAT TRANSFER FROM FLOODED WICK COVERED
SURFACES
U.S. ATOMIC ENERGY COM. CONTRACT AT-(40-1)-3411, NORTH
CAROLINA STATE UNIVERSITY, APRIL 1969. (PART 3), AVAIL. TAC

11100 FERRELL J K JOHNSON H R 70051 C.2-02
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
U. S. ATOMIC ENERGY COM. CONTRACT AT-(40-1)-3411, NORTH
CAROLINA STATE UNIVERSITY, APRIL 1969. (PART 4), (ORO-3411-
12) AVAIL TAC

11200 FERRELL J K ALLEAVITCH J 69067 C.2-02
VAPORIZATION HEAT TRANSFER IN CAPILLARY WICK STRUCTURES
AICHE PREPRINT 6, ELEVENTH NAT'L. HEAT TRANSFER CONF.,
MINNEAPOLIS, MINN., AUG. 3-6, 1969. AVAIL. TAC

11300 FERRELL J K CARNESALE A 67059 E-02
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
5TH QUARTERLY PROGRESS REPORT (TID-23503, OCT. 1, 1966)
AVAIL. TAC

11400 FERRELL J K CARNESALE A 67041 C.A-02
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
6TH QUARTERLY PROGRESS REPORT (TID-23809, FEB. 1, 1967)
AVAIL. TAC

11500 FERRELL J K CARNESALE A 67036 C.1-02
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
PROGRESS REPORT (TID-23937 JULY 1, 1967), AVAIL. TAC

11600 FERRELL J K 68048 E-03
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
9TH QUARTERLY PROGRESS REPORT (ORO3411-9, NOV. 1, 1967)
AVAIL. TAC

11700 FERRELL J K 68029 C.3-01
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
10TH QUARTERLY PROGRESS REPORT (ORO3411-10, FEB. 20, 1968)
AVAIL. TAC

11800 FERRELL J K 68049 E-03
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
11TH QUARTERLY PROGRESS REPORT (ORO3411-11, APRIL 1, 1968)
AVAIL. TAC

11900 FIEBELMANN P 69082 D.1-05
HEAT PIPES
U.S. PATENT 3,414,475 TO EURATOM, DEC. 3, 1968.

12000 FIEBELMANN P NEU H 69020 B.2-10
RINALDINI C
A HEAT PIPE THERMIONIC REACTOR CONCEPT
PROC. SECOND INTERN'L CONF. ON THERMIONIC ELEC. POWER
GENERATIONS, STRESSA, ITALY. (A69-29172 14-03), MAY 27-31,
1968. AVAIL. TAC

12100 FLAHERTY R 70014 B.2-13
THERMALLY CASCADED THERMOELECTRIC GENERATOR
(PATENT APPLICATION) JET PROPULSION LAB. CALIF. INST. OF
TECH, PASADENA. (CONTRACT NAS7-100) (NASA-CASE-NPO-10753, US
PATENT APPL. SN-844 355) AVAIL. TAC

12101 FORMAN R 71003 B.1-05
TECHNIQUE FOR THE DIRECT MEASUREMENT OF THERMAL CONDUCTIVITY
AT HIGH TEMPERATURES BY THE USE OF A HEAT PIPE
(NASA-TM-X-52909) OCT. 1970, 17 P. AVAIL TAC

12200 FRADKIN D B BLACKSTOCK A W 69007 B.1-03
ROEHLING D J STRATTON T F
WILLIAMS M LIEWER K W
EXPERIMENTS USING A 25KW HOLLOW CATHODE LITHIUM VAPOR MPD
ARC JET
AIAA, ELECTRIC PROPULSION CONF. 7TH WILLIAMSBERG, VA. MARCH
3-5 1969 PAPER 69-241, 16 PAGES. AVAIL TAC

12300 FRANK S SMITH J T 68037 D.1-03
TAYLOR K M
HEAT PIPE DESIGN MANUAL
MARTIN MARIETTA CORP. REPORT, MND-3288, FEB 1967 (DENVER, COLO.)

12400 FRANK S 67046 D.1-02
OPTIMIZATION OF A GROOVED HEAT PIPE
ASME-ADVANCES IN ENERGY CONVERSION ENGRG., MIAMI, FLORIDA, AUG. 1967, PP. 833-845, AVAIL TAC

12500 FRANK T G ANDERSON R C 68009 B.2-07
SMALL OUT-OF-PILE THERMIONIC CONVERTER
LOS ALAMOS SCIENTIFIC LAB, NEW MEXICO 16 APRIL 1968 8 P. REFS (CONTRACT W-7405-ENG-36) (LA-3813), AVAIL. TAC

12600 FREA W J HAMELINK J H 70052 C.2-03
HEAT TRANSFER FROM THE WALL OF A POROUS SOLID INVOLVING GAS INJECTION AND VAPORIZATION
JOURNAL OF HEAT TRANSFER, FEB. 1970 P. 153-8. AVAIL. TAC

12700 FREGGENS R A 69087 D.2-03
EXPERIMENTAL DETERMINATION OF WICK PROPERTIES FOR HEAT PIPE APPLICATIONS
PROC. OF TH 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., WASHINGTON, D. C. SEPT. 22-26, 1968, PP. 888-897. AVAIL. TAC

12701 FREGGENS R A 70017 B.2-13
ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY - TOPICAL REPORT
TASK 2 - DEVELOPMENT OF ADSCRPTION RESERVOIR
MARCH 1, 1969 - SEPT 30, 1969 (RCA CORP., LANCASTER, PA.)
CONTRACT AT(30-1(-3979 (48P.) AVAIL TAC

12800 FRYSINGER G R EASTMAN G Y 66012 B.2-04
THREE KW FLAME HEATED THERMIONIC ENERGY CONVERTER
PROC. 20TH ANNUAL POWER SOURCES CONF. 1966 P. 169-171. AVAIL. TAC

12900 GALOWIN L S BARKER V A 69074 C.4-03
HEAT PIPE CHANNEL FLOW DISTRIBUTIONS
ASME 69-HT-22 AVAIL. TAC

13101 GERRELS E E LARSON J W 71011 B.3-10
BRAYTON CYCLE VAPOR CHAMBER (HEAT PIPE) RADIATOR STUDY
CONTRACT NAS3-10615, GESP-7030, FEB 1971, 279 P., AVAIL. TAC

13200 GILLOT R H NEU H 67021 B.2-06
VAN ANDEL E
EURATOM'S ACTIVITY IN RADIOISOTOPE POWERED THERMOELECTRIC
AND THERMIONIC GENERATORS
INDUSTRIAL APPLICATIONS FOR ISOTOPIC POWER GENERATORS, PP.
461-82 PARIS, EUROPEAN NUCLEAR ENERGY AGENCY 1967. AVAIL.
TAC

13300 GRAUMANN D W 67051 D.2-02
RESEARCH STUDY ON INSTRUMENT UNIT THERMAL CONDITIONING HEAT
SINK CONCEPTS
QUARTERLY PROGRESS PEPORT JUNE 1 - AUG 31, 1966. CONTRACT
NAS8-11291 (NASA-CR82794, REPT. 66-1174, QPR-2) 24P., AVAIL.
TAC

13400 GRAUMANN D W 67054 D.2-02
RESEARCH STUDY ON INSTRUMENT UNIT THERMAL CONDITIONING HEAT
SINK CONCEPTS
QUARTERLY PROGRESS REPORT, SEPT. 1 - NOV. 30, 1966 GARRETT
CORP., LOS ANGELES, CALIF. AIRESEARCH MANUFACTURING DIV.
CONTRACT NAS8-11291 (NAS8-CR-89618, REPT-66-1491) 52 P.
AVAIL. TAC

13500 GRAY V H 69081 D.1-04
THE ROTATING HEAT PIPE - A WICKLESS HOLLOW SHAFT FOR
TRANSFERRING HIGH HEAT FLUXES
ASME AND AICHE HEAT TRANSFER CONF., MINNIAPOLIS, MINN.,
(ASME PAPER 69-HT-19), AUG. 3-6, 1969. AVAIL. TAC

13501 GREGORY F C 70058 C.3-02
AN INVESTIGATION OF NUCLEATE BOILING FROM MESH COVERED
SURFACES
M. S. THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF.
(AD-709097) (64 P.), AVAIL. TAC

13600 GRITTON E C PINKEL B 70018 B.2-13
GASEOUS-CORE REACTOR CONCEPT FOR ELECTRICAL POWER GENERATION
NUCLEAR APPLICATIONS AND TECHNOLOGY V. 8 NO. 4 APRIL 1970,
P. 355-70. AVAIL. TAC

13700 GROLL M ZIMMERMANN P 70047 C.1-05
PARAMETERS FOR THE ASSESSMENT OF HEAT CARRIERS IN HEAT PIPES
INST. KERNENERG, UNIV. STUTTGART, STUTTGART, GERMANY, CHEM.
-ING.-TECH. 1969, 41(24), 1294-1300 (GERMAN) AVAIL. TAC

13701 GROLL M ZIMMERMANN P 70055 C.2-03

MAXIMUM HEAT TRANSPORT OF OPTIMALLY DESIGNED HEAT PIPES
CHEMIE - ING. - TECHNIK 1970, 42 (15). 977-81 (IN GERMAN)
AVAIL TAC

13702 GROLL M ZIMMERMANN P 70090 E-09
UNSTEADY OPERATING BEHAVIOR OF HEAT PIPES
CHEMIE - ING. - TECH. 1970, 42(16), 1031-4 (IN GERMAN)
AVAIL TAC

13800 GROSSE A V CAHILL J A 67007 B.1-01
HIGH TEMPERATURE INORGANIC CHEMISTRY
TEMPLE UNIVERSITY RESEARCH INST., PHILADELPHIA, PENNSYLVANIA
CONTRACT (AT(30-1)-2082), (RITV-1966-18, APRIL 8, NYO-2082-6
AVAIL. TAC

13900 GROVER G M 66002 A-01
EVAPORATION-CONDENSATION HEAT TRANSFER DEVICE
U.S. PATENT NO. 3,229,759, JAN. 18, 1966

13901 GROVER G M BUSSE C A 69028 B.2-12
CORON R J
THERMIONIC CONVERTER DEVICE
PATENT USA 3441752, 23 OCT. 1965 PUBLISHED 29 APRIL 1969.

14000 GROVER G M BOHDANSKY J 67019 B.2-05
BUSSE C A
NUCLEAR REACTOR WITH THERMIONIC CONVERTER
U.S. PATENT 3,302,042, JAN. 31, 1967.

14100 GROVER G M BOHDANSKY J 67024 B.2-06
BUSSE C A
THE USE OF A NEW HEAT REMOVAL SYSTEM IN SPACE THERMIONIC
POWER SUPPLIES
EUROPEAN ATOMIC ENERGY COMMUNITY-EURATOM, REPORT NO. EUR
2229.E, 1965 AVAIL. TAC

14200 GROVER G M COTTER T P 64001 C.2-01
ERICKSON G F
STRUCTURES OF VERY HIGH THERMAL CONDUCTANCE
J. OF APPLIED PHYSICS, VOL 35, JUNE 1964, PP. 1990-1991
AVAIL. TAC

14300 GROVER G M KEMME J E 69028 B.2-12
KEDDY E S
ADVANCES IN HEAT PIPE TECHNOLOGY

LOS ALAMOS SCI. LAB. REPORT, LA-DC-9619, 1968.

14400 HALL W B 66033 E-01
HEAT PIPE EXPERIMENTS
IEEE CONF. RECORD OF THE 1965 THERMIONIC CONVERSION
SPECIALISTS CONF. SAN DIEGO, CALIF., 1965, PP. 337-340.
AVAIL. TAC

14500 HALL W B KESSLER S W 67049 D.1-02
ADVANCES IN HEAT PIPE DESIGN
PROC. OF THE 20TH ANNUAL POWER SOURCES CONF.,FORT MONMOUTH,
NEW JERSEY, MAY 1966. AVAIL. TAC

14501 HALL W B KESSLER S W 65010 B.2-01
THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE
WITH THERMIONIC ENERGY CONVERTERS
RCA DIRECT ENERGY CONVERSION DPT. QUART. TECH. RPT. NO. 2.
MAY 1966.

14502 HALL W B KESSLER S W 66008 B.2-03
THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE
WITH THERMIONIC ENERGY CONVERTERS
RCA DERECT ENERGY CONVERSION DPT. QUART. TECH. RPT. NO. 3
JULY 1966

14503 HALL W B KESSLER S W 66009 B.2-03
THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE
WITH THERMIONIC ENERGY CONVERTERS
RCA DIRECT ENERGY CONVERSION DPT. FINAL RPT., SEPT. 1966

14600 HALLER H C 65003 B.1-01
ANALYSIS OF A DOUBLE FIN-TUBE FLAT CONDENSER-RADIATOR AND
COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR
NASA TN D-2558, 1964. AVAIL. TAC

14700 HALLER H C LIEBLEIN S 71040 B.3-11
FEASIBILITY STUDIES OF SPACE RADIATORS USING VAPOR CHAMBER
FINS
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB. HEAT
PIPE CONF., VOL. 1, OCT. 1966. AVAIL. TAC

14800 HALLER H C LIEBLEIN S 65004 B.1-01
LINDOW B G
ANALYSIS AND EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR
FOR HIGH-POWER RANKINE CYCLES

NASA LEWIS RESEARCH CENTER. NASA TN D-2836, CLEVELAND, OHIO,
MAY 1965 AVAIL. TAC

14900 HALLER H C LINDOW B G 66017 C.1-01
AUER B M
ANALYSIS OF LOW-TEMPERATURE DIRECT-CONDENSING VAPOR-CHAMBER
FIN AND CONDUCTION FIN RADIATORS
LEWIS RESEARCH CENTER. NASA TN D-3103, CLEVELAND, OHIO, MAY
1965. AVAIL. TAC

15000 HAMPEL V E KOOPMAN R P 69050 B.4-02
REACTIVITY SELF-CONTROL ON POWER AND TEMPERATURE IN REACTORS
COOLED BY HEAT PIPES
CALIFORNIA UNIV., LIVERMORE LAWRENCE RADIATION LAB., NOV. 1,
1968. CONTRACT W-7405-ENG-48. 83 P. (CONF-681101-9)
AVAIL. TAC

15100 HARBAUGH W E 65007 B.2-01
THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER HEAT
PIPE ASSEMBLY
RADIO CORP. OF AMERICA TECH. REPORT, AFAPL-TR-66-37, JUNE
1966. AVAIL. TAC

15101 HARBAUGH W E 65008 B.2-01
DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER HEAT PIPE
ASSEMBLY
QUART. TECH. RPT. NO. 2

15102 HARBAUGH W E 65009 B.2-01
DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER HEAT PIPE
ASSEMBLY
QUART. TECH. RPT. NO. 3

15103 HARBAUGH W E 66006 B.2-03
DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER HEAT PIPE
ASSEMBLY
QUART. TECH. RPT. NO. 4

15104 HARBAUGH W E 66007 B.2-03
DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER HEAT PIPE
ASSEMBLY
SUMMARY TECH. RPT.

15200 HARBAUGH W E EASTMAN G Y 71043 B.1-05
EXPERIMENTAL EVALUATION OF AN AUTOMATIC TEMPERATURE

CONTROLLED HEAT PIPE
INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., BOULDER, COLO., AUG. 13-17, 1968.

15300 HARBAUGH W E LONGSDERFF R W 68015 B.2-08
THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER - HEAT PIPE ASSEMBLY
IEEE CONF. RECORD OF THE 1966 THERMIONIC CONVERSION SPECIALIST CONF., HOUSTON, TEXAS, NOV 3-4, 1966, PP. 139-143. AVAIL. TAC

15400 HARKNESS R E 70080 E-07
THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND IN ORBIT
APPLIED PHYSICS LAB., JOHN HOPKINS UNIV., REPORT NO. NASA-CR 107686, APRIL 1., 1968. AVAIL. TAC

15500 HARKNESS R E 69040 B.3-06
PERFORMANCE OF THE GEOS-2 HEAT PIPE SYSTEM
APL TECHNICAL DIGEST, VOL. 8, MY, JN 1969, P 14-49, AVAIL. TAC

15600 HASKIN W L 67044 D.1-01
CRYOGENIC HEAT PIPE
AIR FORCE FLIGHT DYNAMICS LAB., WRIGHT-PATTERSON AFB, OHIO, JUNE 1967. (FINAL REPORT) AVAIL TAC

15700 HEATH C A LANTZ E 68013 B.2-07
A REACTOR CONCEPT FOR SPACE POWER EMPLOYING THERMIONIC DIODES AND HEAT PIPE
AIAA, AERO. SCI. MEETING, 5TH, PAPER NO. 68-122, NEW YORK, N.Y. JAN. 22-24, 1967 (NASA-TM-X-52370), AVAIL. TAC

15800 HEATH C A LANTZ E 68010 B.2-07
NUCLEAR THERMIONIC SPACE POWER SYSTEM CONCEPT EMPLOYING HEAT PIPES
LEWIS RESEARCH CENTER, NASA TN D-4299, CLEVELAND, OHIO, MARCH 1968. AVAIL. TAC

15801 HICKOX O J 70074 D.2-05
A STUDY OF WIRE MESH WICK CHARACTERISTICS IN A LONGITUDINAL HEAT PIPE
M.S. THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF. (AD-709108) (71 P.), AVAIL. TAC

15900 HINDERMAN J D MADSEN J 69037 B.3-05
WATERS E D
AN ATS-E SOLAR CELL SPACE RADIATOR UTILIZING HEAT PIPES
AIAA, THERMOPHYSICS CONF. 4TH SAN FRANCISCO, CALIF. JUNE 16-18, 1969 PAPER 69-630 7P., AVAIL. TAC

15901 HINDERMAN J D WATERS E D 71026 D.1-07
KASER R V
DESIGN AND PERFORMANCE OF NONCONDENSIBLE GAS CONTROLLABLE HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-4208 AVAIL. TAC

15910 HOLM F W 71018 C.1-06
THERMAL SCALE MODELING OF A HEAT PIPE
PHD THESIS 1969, KANSAS STATE UNIVERSITY, MANHATTAN, KANSAS, 82 P., AVAIL. TAC

16000 HOLM F W MILLER P L 70046 C.1-05
THERMAL SCALE MODELING OF A HEAT PIPE
ASME PAPER 70-HT/SPT-14 AVAIL. TAC

16001 HOLMGREN J S 70081 E-07
PRELIMINARY PROGRAM PLAN HEAT PIPE PARAMETRIC DATA
MCDONNEL-DOUGLAS CO. RICHLAND, WASH. DONALD W. DOUGLAS LABS. AUG. 1969 (22 P.), AVAIL. TAC

16100 HUFSCHMIDT W BURCK E 69078 C.4-04
DICOLA G HOFFMANN H
LIQUID-VAPOR INTERACTION IN HEAT PIPES
WAERME-UND STOFFUEBERTRAGUNG VOL. 2 (1969) P. 222-239 (IN GERMAN) AVAIL. TAC

16101 HUNSBERGER D L CHATO J C 71030 E-09
EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE OF VARIOUS WICK CONFIGURATIONS IN SINGLE AND TWO FLUID HEAT PIPES OPERATING IN THE GRAVITATIONAL FIELD
GRANT NGR-14-005-103 (NASA-CR-111760, ME-TR-187), OCT. 1970, 46 P., AVAIL. TAC

16110 IVANOVSKII M N SOROKIN V P 71033 E-10
SUBBOTIN V I SHUSTOV M V
INVESTIGATION OF HEAT AND MASS TRANSFER IN A HEAT PIPE WITH A SODIUM COOLANT
HIGH TEMPERATURE (USSR, ENGL. TRANSL) VOL. 8, MAR.-APRIL 1970, P. 299-304, AVAIL. TAC

16200 JANSSEN M 66025 C.4-01
VISCOUS FLOW IN A RECTANGULAR CHANNEL HEAT PIPE WICK
LAWRENCE RAD. LAB., LIVERMORE, CALIF., UCID-15518 ALSO
SPACE POWER NOTE NO. 195, NOV. 4, 1966. AVAIL. TAC

16300 JEFFERIES N P 67032 B.3-03
FABRICATION AND TEST OF AN ALUMINUM HEAT PIPES
GENERAL ELECTRIC MEMO. REPORT HTC-7, GENERAL ELEC. CO.,
CINCINNATTI, OHIO, FEB. 1967. AVAIL. TAC

16400 JOHNSON G D 68042 D.3-01
COMPATIBILITY OF VARIOUS HIGH-TEMP. HEAT PIPE ALLOYS WITH
WORKING FLUIDS
IEEE CONF. RECORD OF THE 1968 THERMIONIC CONVERSION
SPECIALIST CONF., 7TH CONF., FRAMINGHAM, MASS., OCT. 21-23,
1968, PP. 258-265. AVAIL. TAC

16600 JOHNSON G D 70075 D.3-02
CORROSION STUDIES OF LIQUID METAL HEAT PIPE SYSTEMS AT 1000
TO 1800C
METALLURGICAL SOCIETY OF AIME, FALL MEETING, PHILADELPHIA,
PA., OCT. 13-16, 1969. PAPER F69-2, 17P., AVAIL. TAC

16700 JOY P 70067 D.1-06
OPTIMUM CRYOGENIC HEAT PIPE DESIGN
ADVANCED TECHNOLOGY LABS - DEFENCE ELECTRONIC PRODUCTS, RCA
CAMDEN, N.J., ASME PAPER 70-HT/SPT-7. AVAIL. TAC

16800 JUDGE J F 66032 E-01
RCA TEST THERMAL ENERGY PIPE
MISSILES AND ROCKETS, FEB. 21, 1966, PP. 36-38. AVAIL. TAC

16801 KALKBRENNER R W 70003 A-04
HEAT TRANSFER DEVICE
PATENT APPLICATION FILED 21 MAY 1970 (US-PTNT-APPL-SN-39343)
(NASA-CASE-NPO-11120) (13P.) ,AVAIL. TAC

16900 KATZOFF S 67045 D.1-02
HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF
SPACECRAFT
PROC. OF THE AIAA THERMOPHYSICS SPECIALISTS CONF., AIAA
PAPER NO. 67-310, NEW ORLEANS, LOUISIANA, APRIL 17-20, 1967.
AVAIL. TAC

17000 KATZOFF S 67028 B.3-02

NOTES ON HEAT PIPES AND VAPOR CHAMBERS AND THEIR APPLICATION TO THERMAL CONTROL OF SPACECRAFT
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB. HEAT PIPE CONF.. VOL. 1. OCT. 1966. AVAIL. TAC

17100 KEMME J E 67052 D.2-02
HEAT PIPE CAPABILITY EXPERIMENTS
PROC OF JOINT ATOMIC ENERGY COMMISSION/SANDIA LAB. HEAT PIPE CONF., VOL. 1, ALBUQUERQUE, NEW MEXICO, OCT. 1966. AVAIL. TAC

17200 KEMME J E 67050 D.2-01
HEAT PIPE CAPABILITY EXPERIMENTS
LOS ALAMOS SCIENTIFIC LAB. NEW MEXICO CONTRACT W-7405-ENG-36 (LA-3585-MS) AVAIL. TAC

17300 KEMME J E 68026 C.1-03
HEAT PIPE CAPABILITY EXPERIMENTS
IEEE CONF. RECORD OF THE 1966 THERMIONIC CONVERSION SPECIALISTS CONF., HOUSTON, TEXAS, NOV. 3-4, 1966, PP. 159-168. AVAIL. TAC

17400 KEMME J E 68040 D.2-03
HIGH PERFORMANCE HEAT PIPE
IEEE CONF. RECORD OF THE 1967 THERMIONIC CONVERSION SPECIALIST CONF., PALO ALTO, CALIF., OCT. 30 - NOV. 1, 1967, 355-358. (CONF-671045-4),(LA-DC-9027) AVAIL TAC

17500 KEMME J E 69084 D.1-05
HEAT PIPE DESIGN CONSIDERATIONS
LOS ALAMOS SCI. LAB. REPORT, LA-4221-MS, AUG 18 1969. AVAIL. TAC

17600 KEMME J E 69073 C.4-03
ULTIMATE HEAT PIPE PERFORMANCE
IEEE THERMIONIC CONVERSION SPECIALIST CONF., (7TH), FRAMINGHAM, MASS., OCT. 21-23, 1968, PP. 717-723. (IEEE TRANS. ELECTR DEV. AUG. 69) AVAIL. TAC

17700 KILMARTIN H E JR 70072 D.2-04
THE EFFECT OF WICK GEOMETRY ON THE OPERATION OF A LONGITUDINAL HEAT PIPE
NAVAL POSTGRADUATE SCHOOL, M. S. THESIS, MONTEREY, CALIF., JUNE 1969. AVAIL. TAC

17710 KIRKPATRICK J P   MARCUS B D ,   71038   E-11
A VARIABLE CONDUCTANCE HEAT PIPE FLIGHT EXPERIMENT
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-411, AVAIL TAC

17800 KOEPPE A   68023 B.4-02
EXPERIMENTS FOR SIMULATING HEAT TRANSFER FROM A REACTOR SURFACE TO CESIUM VAPOR CONVERTERS
STUTTGART UNIVERSITY (WEST GERMANY) FEB. 15, 1968. 17P. (IN GERMAN), AVAIL. TAC

17900 KOLACH T A   70057 C.3-02
INVESTIGATION OF HEAT EXCHANGE WITH BOILING WATER DELIVERED TO THE HEATING SURFACE BY A CAPILLARY POROUS BODY AT LOW PRESSURES
17 DEC. 1969 18 P REFS. TRANSL. INTO ENGLISH FROM INZH - FIX ZH. (MOSCOW), V. 14, JUNE 1958 P. 975-982. IN ENGLISH AND RUSSIAN (NLL-CE-TRANS-5098-(9022-09)) AVAIL. TAC

17901 KROEGER E W   71006 B.2-14
FABRICATION AND EVALUATION OF AN OUT-OF-CORE THERMIONIC CONVERTER MODULE
THERMIONIC CONVERSION SPECIALIST CONF., MIAMI, FLA. 26-29 OCT. 1970 (IEEE) (NASA-TM-X-52934, E-6066), 8 P., AVAIL. TAC

17910 KOSOWSKI N   KOSSON R   71037   E-11
EXPERIMENTAL PERFORMANCE OF GROOVED HEAT PIPES AT MODERATE TEMPERATURES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-409, AVAIL. TAC

18000 KUCHEROV R Y   RIKENGLAZ L E   60001 C.3-01
ON HYDRODYNAMIC BOUNDARY CONDITIONS FOR EVAPORATION AND CONDENSATION
SOVIET PHYSICS JETP VOL. 37 (10) NO. 1, JAN. 1960, P. 88-9
AVAIL. TAC

18100 KUNZ H R   LANGSTON L S   67053 D.2-02
HILTON B H   WYDE S S
NASHICK G H
VAPOR-CHAMBER FIN STUDIES - TRANSPORT PROPERTIES AND BOILING CHARACTERISTICS OF WICKS
PRATT AND WHITNEY AIRCRAFT, NASA CR-812, EAST HARTFORD, CONN JUNE 1967. AVAIL. TAC

18200 KUNZ H R   WYDE S S   68047   E-03

NASHICK G H BARNES J F
VAPOR-CHAMBER FIN STUDIES - OPERATING CHARACTERISTICS OF FIN MODELS
PRATT AND WHITNEY ARICRAFT. NASA CR-1139. PWA-3154. EAST HARTFORD. CONN.. JULY 1967. AVAIL. TAC

18201 KUO S C Y 70019 B.2-14
THERMOELECTRIC - BIOMEDICAL HEAT PIPE
DREXEL INST. OF TECH.. PHILADELPHIA. PROC 8TH INT. CONF. ON MED. AND BIOL. ENG. AND 22ND ANN. CONF. ON ENG. IN MED. AND BIOL.. CHICAGO. ILL. JULY 20-25 1969. SESSION 13-10. (1P.) AVAIL. TAC

18300 LANGSTON L KUNZ H R 66028 D.2-01
VAPOR-CHAMBER FIN STUDIES
NASA-CR-54882. SEPT. 1965. (FIRST QUARTERLY REPORT). AVAIL. TAC

18400 LANGSTON L S KUNZ H R 71044 D.2-06
LIQUID TRANSPORT AND HEAT TRANSFER PROPERTIES OF HEAT PIPE WICKING MATERIALS
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB. HEAT PIPE CONF.. SC-M-66-623. VOL. 1. OCT. 1966.

18500 LANGSTON L S KUNZ H R 69090 D.2-04
LIQUID TRANSPORT PROPERTIES OF SOME HEAT PIPE WICKING MATERIALS
ASME AND AICHE HEAT TRANSFER CONF.. MINNEAPOLIS. MINN.. ASME PAPER 69-HT-17. AUG. 3-6. 1969. AVAIL. TAC

18600 LANGSTON L S SHERMAN A 66029 D.2-01
HILTON B H
VAPOR CHAMBER FIN STUDIES
NASA-CR-54922. SEPT. 1 - NOV. 30. 1965
(SECOND QUARTERLY REPORT).AVAIL TAC

18700 LANGSTON L S SHERMAN A 66030 D.2-01
HILTON B H
VAPOR-CHAMBER FIN STUDIES
THIRD QUARTERLY REPORT 1 DEC. 1965 - 28 FEB. 1966. PRATT AND WHITNEY AIRCRAFT. EAST HARTFORD. CONN.. CONTRACT NAS3-7622 (NASA-CR-54989 PNA-2818) 131 P. AVAIL. TAC

18800 LARKIN B S 68030 C.4-02
HEAT TRANSFER IN A TWO-PHASE THERMOSYPHON TUBE
CANADA NATIONAL RESEARCH COUNCIL. DIVISION OF MECHANICAL

ENGINEERING AND NATIONAL AERONAUTICAL ESTABLISHMENT.
QUARTERLY BULLETIN, NO. 3, 1967 P. 45-53, AVAIL TAC

18900 LAUB J H MCGINNESS H D 62001 C.4-01
RECIRCULATION OF A TWO-PHASE FLUID BY THERMAL AND CAPILLARY PUMPING
JET PROPULSION LAB., PASADENA, CALIF., REPORT NO. 32-196.
DEC. 8, 1961.

19000 LAZARIDIS L J PANTAZELOS P G 67025 B.2-06
TESTS ON FLAME HEATED THERMIONIC DIODE
PROC. ANNUAL POWER SOURCES CONF., 1966. AVAIL. TAC

19100 LEE J D WERNER R W 69053 B.4-03
CONCEPT OF A GAS BUFFERED ANNULAR HEAT-PIPE FUEL IRRADIATION CAPSULE
UCRL-71889 (CONF-690910-1) 32 P., AVAIL. TAC

19200 LEE J D WERNER R W 69049 B.4-02
CONCEPT OF A GAS BUFFERED ANNULAR HEAT PIPE FUEL IRRADIATION CAPSULE
LAWRENCE RADIATION LAB., REPORT NO. UCRL-50510, LIVERMORE, CALIF. 1968. AVAIL. TAC

19300 LEEFER B I 66013 B.2-04
NUCLEAR-THERMIONIC ENERGY CONVERTER
NASA PROC. 20TH ANNUAL POWER SOURCES CONF. 1966, P. 172-175. AVAIL. TAC

19401 LEVEDAHL W J 70015 B.2-13
THERMIONIC CONVERTER ASSEMBLIES
BRITISH PATENT 1,182.799 (4 MAR. 1970) PRIORITY DATE 7 NOV. 1966 U.S.

19500 LEVY E K 69071 C.4-02
THEORETICAL INVESTIGATION OF HEAT PIPES OPERATING AT LOW VAPOR PRESSURE
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19, 1968, PP. 671-676. AVAIL. TAC

19501 LEVY E K CHOU S 70062 C.4-04
VAPOR COMPRESSIBILITY EFFECTS IN HEAT PIPES
PROGRESS RPT. NO. 1. MAY 1970 (DPT MECH. ENGRG.,LEHIGH UNIV. BETHLEHEM, PA) CONTRACT AT(30-1)-4095 (76P.) TAC (NYO-4095-1), AVAIL. TAC

19510 LEVY E K 71022 C.4-05
EFFECTS OF FRICTION ON THE SONIC VELOCITY LIMIT IN SODIUM
HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-
407, AVAIL. TAC

19600 LOEWE W E 69012 B.2-08
INVESTIGATION OF PERFORMANCE OF AN OUT-OF-CORE THERMIONIC
SPACE POWER SYSTEM
CALIF. UNIV., LIVERMORE, LAWRENCE RADIATION LAB. 18 MARCH
1968, 24 P. REFS. (UCRL-70984 CONF. 680802-5) AVAIL. TAC

19700 LOEWE W E 69017 B.2-09
ANALYSIS OF AN OUT-OF-CORE THERMIONIC SPACE POWER SYSTEM
CALIF. UNIV. LAWRENCE RADIATION LAB., LIVERMORE CALIF. IEEE
TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS VOL. AES-5,
JAN. 1969, P. 58-65. 19 REFS. AVAIL. TAC

19800 LOEWE W E 69021 B.2-10
OUT-OF-CORE THERMIONIC SPACE POWER
CALIF. UNIV. LIVERMORE, LAWRENCE RADIATION LAB., MARCH 8,
1968. CONTRACT W-7405-ENG.-48. 10 P. (CONF-680508-1), AVAIL.
TAC

19900 LONGSDERFF R W EASTMAN G Y 69029 B.2-12
HARBAUGH W E
DEVELOPMENT OF THREE CONVERTER HEAT PIPE - THERMIONIC MODULE
IEEE TRANS. ON ELECT. DEVICES V.ED-16 N.2, FEB. 1969, P.
259. AVAIL. TAC

20000 LONGSDERFF R W 69015 B.2-09
ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY - DEVELOPMENT OF
HIGH VOLTAGE MODULE
RADIO CORP. OF AMERICA, REPORT NO. NYO-3979-1, LANCASTER,
PA., FEB. 28, 1969., AVAIL. TAC

20001 LONGSDERFF R W 70013 B.2-12
ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY
DEVELOPMENT OF HIGH VOLTAGE MODULE
FINAL TECH. RPT. 1 MAY 1968 - 30 SEPT. 1969. RCA LANCASTER.
PA. CONTRACT AT(30-1)-3979. (NYO-3979-3) (47P.). AVAIL. TAC

20100 LOPER O J 69009 B.1-04
THE HEAT PIPE AND SOME POTENTIAL NAVAL APPLICATIONS
OFFICE OF NAVAL RESEARCH, WASHINGTON, D. C., AUG. 1969, PP.
17-21.

20200 LYMAN F A HUANG Y S 69063 C.1-04
ANALYSIS OF TEMPERATURE DISTRIBUTIONS IN HEAT PIPE WICKS
ASME PAPER 69-HT-23, AVAIL. TAC

20400 MARCUS B D FLEISCHMAN G L 70087 E-08
STEADY-STATE AND TRANSIENT PERFORMANCE OF HOT RESERVOIR GAS-CONTROLLED HEAT PIPES
MATERIALS SCIENCE DEPT., TRW SYSTEMS GROUP, REDONDO BEACH, CALIF. ASME-PAPER 70-HT/SPT-11 AVAIL. TAC

20500 MARCUS B D 65002 A-01
ON THE OPERATION OF HEAT PIPES
TRW SPACE TECH. LAB., ONE SPACE PARK, REDONDO BEACH,CALIF., TRW 9895-6001-TU-000, MAY 1965. AVAIL. TAC

20501 MARTO P J DALEY T J 70043 C.1-05
BALLBACK L J
AN ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF ROTATING NON-CAPILLARY HEAT PIPES
ANNUAL RPT. 30 JUNE 1970 (NASA ORDER-W-13007), (NASA-CR-112657, NPS-59MX70061A) (49 P.), AVAIL. TAC

20600 MARTO P J MOSTELLER W L 69069 C.3-01
EFFECT OF NUCLEATE BOILING ON THE OPERATION OF LOW TEMPERATURE HEAT PIPES
ASME AND AICHE HEAT TRANSFER CONF., ASME PAPER 69-HT-24, MINNEAPOLIS, MINN., AUG. 3-6, 1969. AVAIL. TAC

20700 MCCAULEY E W BROWN N J 69045 B.3-07
ANALYSIS OF ADVANCED FAST-SPECTRUM HEAT SOURCES FOR SPACE APPLICATION
TRANSACTIONS AMERICAN NUCL. SOC. 11 432-3 (NOV. 1968) CONF-681101 AVAIL. TAC

20800 MCKINNEY B G 69095 E-06
AN EXPERIMENTAL AND ANALYTICAL STUDY OF WATER HEAT PIPES FOR MODERATE TEMPERATURE RANGES
GEORGE C. MARSHALL SPACE FLIGHT CENTER, NASA TECH. MEMO, REPORT NO. 53849, JUNE 6, 1969. AVAIL. TAC

20900 MCSWEENEY T I 70082 E-07
THE PERFORMANCE OF A SODIUM HEAT PIPE
AICHE PREPRINT 7, 11TH NAT'L HEAT TRANSFER CONF., MINNEAPOLIS, MINN., AUG. 3-6, 1969. AVAIL. TAC

21000 MILLER P L HOLM F W 70041 C.1-04
INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE
VOL. 1, FINAL RPT. SEPT. 1967 - SEPT. 1969 CONTRACT F33615-68-C-1017 (AD701392, AFFDL-TR-69-91-VOL. 1) (107P.), AVAIL. TAC

21001 MILLER P L HOLM F W 70042 C.1-04
INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE
VOL. 2, FINAL RPT SEPT. 1967 - SEPT. 1969 CONTRACT F33615-68-C-1017 (AD700767, AFFDL-TR-69-91-VOL. 2) (100P.), AVAIL. TAC

21100 MILLER P R JR WIEBELT J A 68019 B.3-03
HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF SPACECRAFT
NASA OFFICE OF TECH. UTILIZATION, JAN. 1968. (EDUCATIONAL MONOGRAPH HT-8-67) AVAIL. TAC

21200 MILLERON N WOLGAST R 69011 B.1-04
CRYOPUMPING OMNITRON ULTRA-VACUUM SYSTEM USING HEAT PIPES AND METAL CONDUCTORS
IEEE TRANS. ON NUCLEAR SCIENCES V. NS-16 NO. 3, JUNE 1969 941-4 AVAIL. TAC

21300 MORITZ K 70048 C.1-06
HEAT PIPE OF NEW CONSTRUCTION - THREADED ARTERY HEAT PIPE
CHEMIE-INGENIEUR-TECHMIC, VOL. 41, NO. 1-2, JAN. 17, 1969, PP. 37-40. (IN GERMAN, TRANSL. AVAIL.) AVAIL. TAC

21400 MORITZ K PRUSCHEK P 70049 C.1-06
LIMITATIONS OF ENERGY TRANSPORT IN HEAT PIPES
CHEMIE-INGENIEUR-TECHNIK, VOL. 41, NO. 1-2, JAN. 17, 1969, PP. 30-37. (IN GERMAN, TRANSL. AVAIL.) AVAIL. TAC

21401 MORITZ K 70044 C.1-05
ON THE EFFECTS OF CAPILLARY GEOMETRY ON OPTIMAL HEATING SURFACE LOADS IN HEAT PIPES
PH.D. THESIS, TECHNISCHE HOCHSCHULE STUTTGART (WEST GERMANY) 27 OCT. 1969 (IN GERMAN TRANSL. AVAIL.) (107 P.), AVAIL. TAC

21500 MOSKVIN Y V FILLINNOV Y N 70006 A-04
HEAT TUBES
HIGH TEMPERATURE, V. 7, N. 4, JULY - AUG. 1969, P 704-713 AVAIL TAC

21600 MOSS R A 69098 E-06
NEUTRON RADIOGRAPHIC EXAMINATION OF VAPOR BUBBLE FORMATION AS A LIMITATION ON PLANAR HEAT PIPE PERFORMANCE
THESIS (PRINCETON UNIVERSITY 1968)

21601 MOSS R A KELLY A J 70084 E-08
NEUTRON RADIOGRAPHIC STUDY OF LIMITING PLANAR HEAT PIPE PERFORMANCE
INT. J.HEAT MASS TRANSFER. 13 491-502 (MAR. 1970).AVAIL TAC

21700 MOUSSEZ C MIHAIL A 67008 B.1-01
THE HEAT PIPE AND THE THERMOSYPHON FOR COOLING GAS TURBINE BLADES
SOCIETE NATIONALE D'ETUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION. DIVISION ATOMIQUE, DEPARTMENT ETUDES THERMIQUES, PARIS, FRANCE, ENTROPIE SEP.-OCT 1966,P 102-109, AVAIL TAC

21800 NEAL L G 68032 D.1-02
AN ANALYTICAL AND EXPERIMENTAL STUDY OF HEAT PIPES
TRW SYSTEMS REPORT NO. 99900-6114-R000 REDONDO BEACH, CALIF., JAN. 1967, AVAIL. TAC

21900 NEU H 66011 B.2-04
HEAT PIPES AND THEIR APPLICATION FOR NUCLEAR POWER SUPPLIES IN SPACE
ATOMPRAXIS 12, APRIL - MAY 1966, PP. 220-224. (IN GERMAN) AVAIL. TAC

21901 NEU H 71002 A-05
HEAT PIPE - A NEW HEAT TRANSFER SYSTEM
SCHWEIZERISCHE TECHNISCHE ZEITSCHRIFT, VOL. 67, DEC. 17, 1970, P. 996-1001 (IN GERMAN), AVAIL. TAC

21910 NIEDERAUER G LANTZ E 71014 B.4-04
A SPLIT-CORE HEAT PIPE REACTOR FOR SPACE POWER APPLICATIONS
THERMIONIC CONVERSION SPECIALIST CONF., MIAMI, FLA., 26-29 OCT., 1970 (IEEE) (NASA-TM-X-52918), 10 P. AVAIL. TAC

22000 PARKER G H HANSON J P 67002 A-01
HEAT PIPE ANALYSIS
WESTINGHOUSE ELECTRIC CORP., INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., MIAMI, 1967 ASME-ADVANCES IN ENERGY CONVERSION ENGRG., AUG. 1967, PP. 847-857. AVAIL. TAC

22100 PEDERSEN E S 67026 B.2-07

HEAT PIPE THERMIONIC REACTOR CONCEPT
NUCLEAR ENGRG., VOL. 12, NO. 129, FEB. 1967, PP. 112-114.
AVAIL. TAC

22200 PETERS J T HANNAH R G 69041 B.3-06
DEVELOPMENT OF AN ADVANCED SPACE RADIATION SYSTEM
PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF.
, PAPER NO. 699125, WASHINGTON D.C., SEPT. 22-26, 1969. PP.
1010-1015. AVAIL. TAC

22300 PHILLIPS E C 69094 E-05
LOW-TEMPERATURE HEAT PIPE RESEARCH PROGRAM
MCDONNELL-DOUGLAS ASTRO. CO. REPORT NO. NASA-CR-66792, DAC-
633661, SANTA MONICA, CALIF., JUNE 24, 1969. AVAIL. TAC

22400 PHILLIPS E C HINDERMAN J D 69088 D.2-04
DETERMINATION OF PROPERTIES OF CAPILLARY MEDIA USEFUL IN
HEAT PIPE DESIGN
ASME 69-HT-18. AVAIL. TAC

22500 PHILLIPS E C HOLMGREN J S 68054 E-05
LOW TEMPERATURE HEAT PIPE RESEARCH
DONALD W. DOUGLAS LAB., REPORT NO. DAC-60752P, RICHLAND,
WASHINGTON, JULY 1968. AVAIL. TAC

22600 PITTS J H WALTER C E 70029 B.3-09
CONCEPTUAL DESIGN OF A 10-MWE NUCLEAR RANKINE SYSTEM FOR
SPACE POWER
CALIF. UNIVERSITY, LIVERMORE, CALIF. JOURNAL OF SPACECRAFT
AND ROCKETS, VOL. 7, MAR. 1970, P. 259-265. 12 REFS. AVAIL.
TAC

22601 PITTS J H WALTER C E 71015 B.4-04
CONCEPTUAL DESIGN OF A 2-MWT (375KWE) NUCLEAR-ELECTRIC SPACE
POWER SYSTEM
J OF SPACECRAFT AND ROCKETS, VOL. 7, NOV. 1970, P. 1282-1286
AVAIL. TAC

22700 PRUSCHEK R SCHINDLER M 67005 A-02
MORITZ K
THE HEAT PIPE
CHEMIE INGR. TECH., VOL. 39, (1), JAN. 13, 1967, P. 21-26.
(IN GERMAN) AVAIL. TAC

22800 PUTHOFF R L 70022 B.3-08

NEUTRONIC DESIGN OF A REACTOR CORE CONTAINING HEAT PIPES FOR APPLICATION TO A NUCLEAR AIRPLANE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS PESEARCH CENTER, CLEVELAND, OHIO (NASA-TM-X-52765 E-5571) (1969) 21 P. REFS. AVAIL.TAC

22900 PUTHOFF R L SILVERSTEIN C C 70024 B.3-08
APPLICATION OF HEAT PIPES TO A NUCLEAR AIRCRAFT PROPULSION SYSTEM
NASA, LEWIS RESEARCH CENTER, CLEVELAND, OHIO. PROPOSED FOR PRESENTATION AT THE 6TH PROPULSION JOINT SPECIALISTS CONF., SAN DIEGO, CALIF., 15-19 JUN. 1970. SPONSORED BY AIAA (NASA-TM-X-52791) AVAIL.TAC

23000 QUAST A 68028 C.3-01
THEORETICAL CONSIDERATIONS ON A VAPORIZATION COOLING SYSTEM WITH CAPILLARY DISTRIBUTOR
DEUTSCHE VERSUCHSANSTALT FUR LUFT-UND RAUMFAHRT, BRUNSWICK (WEST GERMANY) INST FUR STRAHLANTRIEBE. DEC. 1967 23 P. REFS . IN GERMAN ENGLISH SUMMARY (DLR-FB-67-85), AVAIL. TAC

23100 RANKEN W A KEMME J E 66001 A-01
SURVEY OF LOS ALAMOS AND EURATOM HEAT PIPE INVESTIGATIONS
IEEE CONF. RECORD OF THE 1965 THERMIONIC CONVERSION SPECIALIST CONF., SAN DIEGO, CALIF., OCT. 25-27, 1965, PP. 325-336 ALSO LOS ALAMOS REPORT LA-DC-7555, DEC. 1965. AVAIL. TAC

23200 RANKEN W A SUMMERS C S 68021 B.4-01
ISOTHERMAL IRRADIATION ASSEMBLY FOR STUDY OF FAST NEUTRON DAMAGE TO CERAMICS
THERMIONIC CONVERSION SPECIALIST CONF., PALO ALTO, CALIF., 1967. AVAIL. TAC

23400 REICHLE L 70063 C.4-04
THE EFFECT OF GRAVITY ON HEAT TRANSFER IN HEAT PIPES
DEUTSCHE GESELLSCHAFT FUR LUFT AND RAUMFAHRT, JAHRESTAGUNG, BREMEN, WEST GERMANY. SEPT. 22-24, 1969, PAPER 44. 21 P. 12 REFS. ALSO RAUMFAHRTFORSCHUNG V. 14, JAN.-FEB. 1970 P. 13-17 , IN GERMAN, AVAIL. TAC

23401 REIMERS E 71017 B.5-03
CAPACITOR ENERGY STORAGE IMPROVEMENT BY MEANS OF HEAT PIPE
24TH POWER SOURCES SYMPOSIUM, ATLANTIC CITY, N.J. MAY 19-21, 1970, PROCEEDINGS P. 118-122, AVAIL. TAC

23500 REISS F SCHRETZMANN K 69066 C.2-01
PRESSURE BALANCE AND MAXIMUM POWER DENSITY AT THE
EVAPORATION GAINED FROM HEAT PIPE EXPERIMENTS
PROC. SECOND INT. CONF. ON THERMIONIC ELEC. POWER GENERATION
,STRESA, ITALY, 1968, PP. 507-513.(EURNO. 4210 F E)AVAIL.TAC

23600 ROBERTS J J CROKE E J 67033 B.4-01
DESIGN OF A 1 KWE FAST REACTOR POWER SUPPLY
ARGONNE NATIONAL LABORATORY, ARGONNE, ILL. IN ADVANCES IN
ENERGY CONVERSION ENGINEERING AMERICAN SOCIETY OF
MECHANICAL ENGINEERS INTERSOCIETY ENERGY CONVERSION
ENGINEERING CONF., MIAMI BEACH, FLA., AUGUST 13-17, 1967,
PAPERS. (A6742485 24-03) NEW YORK, AMERICAN SOCIETY OF
MECHANICAL ENGINEERS, 1967 P. 575-586. 25 REFS. AVAIL. TAC

23700 ROBERTS J J CROKE E J 69033 B.3-04
CARTER R P NORCO J E
A HEAT-PIPE COOLED FAST REACTOR SPACE POWER SUPPLY
ARGONNE NATIONAL LAB. ILL REACTOR ENG. DIV. CONTRACT W-31
-109-ENG-38 (ANL-7422), AVAIL TAC

23800 ROBERTS J J CROKE E J 69051 B.4-02
COMPACT POWER CONCEPT FEATURES A FAST REACTOR, HEAT PIPES.
AND DIRECT CONVERTERS
REACTOR FUEL-PROCESS TECH., VOL. 11, FALL. 1968, PP. 187-
200. AVAIL. TAC

23810 ROUKIS J ROGOVIN J 71013 B.3-10
SWERDLING B
HEAT PIPE APPLICATIONS TO SPACE VEHICLES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-
410, AVAIL. TAC

23820 ROUSAR D C 70025 B.3-08
HEAT PIPE TECHNOLOGY FOR ADVANCED ROCKET THRUST CHAMBERS
AEROJET LIQUID ROCKET CO., SACROMENTO, CALIF., DEPT OF
ENGINE COMPONENTS. INTERIM RPT. 3 JAN. 1969 - 2 MAY 1970.
(CONTRACT NAS7-697), NASA-CR-110735, RPT. -697-I) (178 P.)
AVAIL. TAC

23821 ROUSAR D C 70031 B.3-09
HEAT PIPE COOLED THRUST CHAMBERS FOR SPACE STORABLE
PROPELLANTS
AIAA PROPULSION JOINT SPECIALIST CONF., 6TH, SAN DIEGO JUNE
15-19, 1970, PAPER 70-942 (7 P.), AVAIL. TAC

23900 RUEHLE R STEINER D 66010 B.2-03
FRITZ R DAGBJARTSSON S
EMPLOYMENT OF HEAT PIPES FOR THERMIONIC REACTORS
ATOMKERN ENERGIE 10, SEPT.-OCT. 1965, PP. 399-404. (IN GERMAN) AVAIL. TAC

24000 SALMI E W 67013 B.2-04
A STUDY OF A NUCLEAR THERMIONIC PROPULSION SYSTEM
LOS ALAMOS SCIENTIFIC LAB., NEW MEXICO (1967) 4 P. PRESENTED AT THE AM. INST. OF AERON. AND ASTRONAUTICS MEETING. NEW YORK (CONTRACT W-7405-ENG-36) (LA-DC-8482 CONF-670111-1) AVAIL.TAC

24100 SAVAGE C J 70021 B.3-08
HEAT PIPES AND VAPOR CHAMBERS FOR SATELLITE THERMAL BALANCE
ROYAL AIRCRAFT ESTABLISHMENT, REPORT NO. RAE-TR-69125, FARNBOROUGH, ENGLAND, JUNE 1969. AVAIL. TAC

24200 SCHACH M 70023 B.3-08
SPACE EXPERIMENT THERMAL DESIGN
NASA GODDARD SPACE FLIGHT CENTER, GREENBELT, MARYLAND, AVAIL TAC

24300 SCHINDLER M WOESSNER G 67039 C.2-01
THEORETICAL CONSIDERATIONS ON HEAT TRANSFER IN HEAT PIPES
ATOMKERN ENERGIE, 10, SEPT. - OCT. 1965 (P. 395-398) (IN GERMAN) AVAIL. TAC

24400 SCHINS H E J 68041 D.3-01
LIQUID METALS FOR HEAT PIPES, PROPERTIES, PLOTS AND DATA SHEETS
EUROPEAN ATOMIC ENERGY COMMUNITY, EUR-3653, ISPRA, ITALY, SEP. 1967. AVAIL. TAC

24500 SCHMIDT E 69077 C.4-04
DETERMINATION OF LOSS OF PRESSURE IN CAPILLARY MEDIA CAPABLE OF BEING USED IN HEAT PIPES
CENTRE D'ETUDES NUCLEAIRES, NOTE TT NO. 265, APRIL 27, 1967. AVAIL. TAC

24600 SCHMIDT E SEMERIA R 69079 D.1-04
THEORETICAL AND EXPERIMENTAL DETERMINATION OF THE LIMITING HEAT POWER TRANSPORTED BY SODIUM HEAT PIPES
PROC. SECOND INT. CONF. ON THERMIONIC ELEC. POWER GENERATION ,STRESA, EUR 4210, 1968, P. 515.(IN FRENCH), AVAIL. TAC

24700 SCHREIBER R E SALMI E W 67016 B.2-05
A LOOK AT NUCLEAR THERMIONIC SYSTEMS
CALIF. UNIV., LOS ALAMOS SCIENTIFIC LAB., LOS ALAMOS, NEW MEXICO AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, PROPULSION JOINT SPECIALIST CONF. 3RD. WASHINGTON, D.C., JULY 17-21, 1967, PAPER 67-498. 7P. AVAIL. TAC

24800 SCHULMAN F 67027 B.3-01
ISOTOPES AND ISOTOPE THERMOELECTRIC GENERATORS
IN NASA LEWIS RES. CENTRE SPACE POWER SYSTEMS ADVANCED TECHNOLOGY CONF. 1966,P. 73-93. AVAIL. TAC

24900 SCHWARTZ J 70088 E-09
PERFORMANCE MAP OF AN AMMONIA HEAT PIPE
JET PROPULSION LAB., CALIF. INST. TECH., PASADENA, CALIF.
ASME PAPER 70-HT/SPT-5 AVAIL. TAC

25000 SCHWARTZ J 69005 A-03
THE HEAT PIPE AND ITS OPERATION
JET PROPULSION LAB., CALIF. INST. OF TECH., PASADENA, CALIF.
REPT 701-21, JAN. 31, 1969. AVAIL. TAC

25100 SCHWARTZ J 69097 E-06
PERFORMANCE MAP OF THE WATER HEAT PIPE AND THE PHENOMENON OF NONCONDENSIBLE GAS GENERATION
ASME 69-HT-15. AVAIL. TAC

25110 SCOLLON T R JR 71012 B.3-10
HEAT PIPE SYSTEM FOR SPACECRAFT THERMAL CONTROL
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-412, AVAIL. TAC

25200 SEMERIA R SCHMIDT E 67020 B.2-05
HEAT PIPES FOR THERMIONIC CONVERTER WITH ISOTOPIC FUEL
INDUSTRIAL APPLICATIONS FOR ISOTOPIC POWER GENERATORS, EUROPEAN NUCLEAR ENERGY AGENCY, PARIS, FRANCE, 1967, PP. 399-409. (IN FRENCH) AVAIL. TAC

25300 SEMERIA R SCHMIDT E 69064 C.1-04
ANALYTICAL AND EXPERIMENTAL STUDY OF SODIUM HEAT PIPES
BULLETIN D'INFORMATIONS SCI. ET TECH. DU CONNISSARIAT A L'ENERGIE ATOMIQUE, NO. 132, 1968 (DEC.) PP. 31-48.

25400 SEROV A SHISHINA V 70028 B.3-09
THERMAL CONTROL

(TERMOREGUL-IROVANIE)AVIATSIIA I KOSMONAVTIKA - JAN. 1970.
P. 26-27. AVAIL. TAC

25500 SHEFSIEK P K 67060 E-02
THERMAL MEASUREMENTS ON A THERMIONIC-CONVERTER - HEAT PIPE SYSTEM
THERMIONIC CONVERSION SPECIALIST CONF., HOUSTON, TEXAS. 1966. AVAIL. TAC

25600 SHEFSIEK P K ERNST D M 69026 B.2-11
HEAT PIPE DEVELOPMENT FOR THERMIONIC APPLICATIONS
PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF. ,WASHINGTON, D.C. SEPT. 22-26, 1969. PP. 879-887. AVAIL. TAC

25601 SHELTON R D 70002 A-04
THE HEAT PIPE EXPERIMENT
NASA MARSHALL SPACE FLIGHT CENTER, 16 SEPT 1969. (NASA-TM-X-53930, MSEC-R-SSL-INN-67-10) (13P.). AVAIL. TAC

25700 SHEPPARD T D JR 69057 B.5-01
HEAT PIPES AND THEIR APPLICATION TO THERMAL CONTROL IN ELECTRONIC EQUIPMENT
NAT'L ELEC. PACKAGING AND PROD. CONF., ANAHEIM, CALIF., FEB. 11-13, 1969 ALSO PROC. OF THE TECH. PROGRAM (A69-39941 22-09), PHILADELPHIA, JUNE 10-12, 1969, PP. 25-52. AVAIL. TAC

25800 SHLOSINGER A P 69047 B.3-07
HEAT PIPES FOR SPACE SUIT TEMPERATURE CONTROL
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19, 1968, PP.644-648. AVAIL. TAC

25900 SHLOSINGER A P 69038 B.3-06
ADVANCEMENTS OF SPACE SUIT TEMPERATURE CONTROL TECHNOLOGY BY APPLICATION OF MODIFIED HEAT PIPES
AIAA THERMOPHYSICS CONF. 4TH SAN FRANCISCO, CALIF., JUNE 16-18, 1969. PAPER 69-619 9P. AVAIL. TAC

26000 SHLOSINGER A P 69032 B.3-04
HEAT PIPE DEVICES FOR SPACE SUIT TEMPERATURE CONTROL
RESEARCH REPORT 30 JUNE 1966 1 SEPT. 1968. TRW SYSTEMS GROUP REDONDO BEACH, CALIF., CONTRACT NO. NAS2-3817 NASA-CR-1400, TRW-046462-6005-R0-00 AVAIL. TAC

26100 SHLOSINGER A P 68016 B.3-03
STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS

FOR ADVANCED SPACE SUITS
TRW SYSTEMS REPORT NO. 06462-6002-R000, CONTRACT NO. NAS 2-3817. (NASA CR-73168) AVAIL.TAC

26101 SHLOSINGER A P WOO W 66014 B.3-01
CAFARO C BENTILLA E W
TECHNOLOGY STUDY OF PASSIVE CONTROL OF HUMIDITY IN SPACE SUITS
CONTRACT NAS2-2102, NASA-CR-69098, NSL-65-87-3), SEPT 1965, 79 P. AVAIL. TAC

26200 SHROFF A M ARMAND M 70004 A-04
THE HEAT PIPE
REVUE TECHNIQUE THOMPSON CSF VOL. 1, DEC. 69, P. 611-648. (IN FRENCH), AVAIL. TAC

26300 SILVERSTEIN C C 70020 B.3-07
A STUDY OF HEAT PIPE APPLICATIONS IN NUCLEAR AIRCRAFT PROPULSION SYSTEMS
FINAL REPORT, REPORT NO. NASA-CR-72610 SIL-104, DEC. 1969. AVAIL. TAC

26400 SILVERSTEIN C C 69008 B.1-03
HEAT PIPE GAS TURBINE REGENERATORS
ASME PAPER 68-WA/GT-7 WINTER ANNUAL MEETING
AVAIL. TAC

26500 SILVERSTEIN C C 68004 B.1-02
PRELIMINARY EVALUATION OF GAS TURBINE REGENERATORS EMPLOYING HEAT PIPES
FINAL TECH. REPORT AD-671-028, APRIL 1968. AVAIL. TAC

26501 SOCKOL P M FORMAN R 71029 E-09
REEXAMINATION OF HEAT PIPE STARTUP
THERMIONIC CONVERSION SPECIALIST CONF., MIAMI, FLA., 26-29 OCT. 1970 (IEEE) NASA-TM-X-52924, 4 P. AVAIL. TAC

26600 SOLIMAN M M GRAUMANN D W 70054 C.2-03
BERENSON P J
EFFECTIVE THERMAL CONDUCTIVITY OF DRY AND LIQUID-SATURATED SINTERED FIBER METAL WICKS
AIRESEARCH MANUF. CO., LOS ANGELES, CALIF., ASME PAPER 70-HT/SPT-40 AVAIL. TAC.

26700 STENGER F J 66024 C.4-01

EXPERIMENTAL FEASIBILITY STUDY OF WATER-FILLED
CAPILLARY-PUMPED HEAT TRANSFER LOOPS
NASA LEWIS RESEARCH CENTER, NASA TM-X-1310, CLEVELAND, OHIO,
NOV. 1966. AVAIL. TAC

26800 STEPHANOU S E WARD T E 69035 B.3-05
HOLMGREN J S
APPLICATION OF HEAT PIPE TECHNOLOGY TO ROCKET ENGINE COOLING
AMER. INST. OF AERO. AND ASTRO. PROPULSION JOINT SPECIALIST
., 5TH U. S. AF ACADEMY, PAPER NO. 69-582. COLO. SPRINGS,
COLO. (J.SPACECRAFT & ROCKETS 7 748-50,JUNE 1970) AVAIL TAC

26900 STRATTON A A WALKER W N 70050 C.2-02
A SHORT STUDY OF CAPILLARY ACTION IN BOILING WATER HEAT
TRANSFER THROUGH POROUS MEDIA
CENTRAL ELECTRICITY GENERATION BOARD, LONDON, ENGLAND.
RESEARCH AND DEVELOPMENT DEPT., JULY, 1969 17 P. (RD/B/N-
1358) AVAIL. TAC

27000 STRECKERT J H CHATO J C 69093 E-05
DEVELOPMENT OF A VERSATILE SYSTEM FOR DETAILED STUDIES ON
THE PERFORMANCE OF HEAT PIPES
DEPT. OF MECH & IND. ENGRG., UNIV. OF ILL. AT URBANA-
CHAMPAIGN, REPORT NO. TR NO. ME-TR-64, DEC. 1968.
NASA CR-100725, AVAIL.TAC

27100 THURMAN J L INGRAM E H 69034 B.3-04
APPLICATION OF HEAT PIPES TO REDUCE CRYOGENIC BOIL-OFF IN
SPACE
J. OF SPACECRAFT & ROCKETS, VOL. 6, NO. 3, MARCH 1969, PP.
319-321. AVAIL. TAC

27101 THURMAN J L MEI S 70026 B.3-08
APPLICATION OF HEAT PIPES TO SPACECRAFT THERMAL CONTROL
PROBLEMS
BROWN ENGRG CO., INC., HUNTSVILLE, ALA. RES. LABS. CONTRACT
NAS8-20073, NASA-CR-109991, TN-AST-275, (102P.), AVAIL. TAC

27200 TIEN C L 69062 C.1-03
TWO-COMPONENT HEAT PIPES
AIAA THERMOPHYSICS CONF., AIAA PAPER NO. 69-631, BERKELEY,
CALIF., JUNE 1969. AVAIL. TAC

27300 TURNER R C 69036 B.3-05
THE CONSTANT TEMPERATURE HEAT PIPE - A UNIQUE DEVICE FOR THE
THERMAL CONTROL OF SPACECRAFT COMPONENTS

AIAA THERMOPHYSICS CONF., 4TH, PAPER NO. 69-632 SAN FRANCISCO, CALIF., JUNE 16-18, 1969. AVAIL. TAC

27400 TURNER R C HARBAUGH W E 69048 B.3-07
DESIGN OF A 50000 WATT HEAT PIPE SPACE RADIATOR
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19, 1968. PP. 639-643. AVAIL. TAC

27500 VAN ANDEL E 69080 D.1-04
HEAT PIPE DESIGN THEORY
INTERN'L CONF. ON THERMIONIC ELEC. POWER GENERATION, 2ND, PROC. A69-29172 14-03, STRESA, ITALY, MAY 27-31, 1968. AVAIL. TAC

27600 VIDAL C R COOPER J 69099 B.1-04
HEAT PIPE OVEN - A NEW WELL-DEFINED METAL VAPOR DEVICE FOR SPECTROSCOPIC MEASUREMENTS
NATIONAL BUREAU OF STANDARDS, BOULDER, COLORADO 80302 J. OF APPL. PHYSICS, VOL. 40, NO. 8, JULY 1969, P. 3370-3374. AVAIL. TAC

27700 WATERS E D KING P P 70078 D.3-02
COMPATIBILITY EVALUATION OF AN AMMONIA-ALUMIMUM-STAINLESS STEEL HEAT PIPE
DONALD W. DOUGLAS LAB., MCDONNEL DOUGLAS CORP.,RICH, WASH. ASME PAPER 70-HT/SPT-15 AVAIL. TAC

27800 WATTS J L 69085 D.1-05
A HEAT-PIPE OPTIMIZATION CODE, LAM2
LAWRENCE RAD. LAB., UCID-15462, UNIV. OF CALIF., LIVERMORE, CALIF., ALSO SPACE POWER NOTE 159, APRIL 2, 1969. AVAIL. TAC

27900 WATTS J L 66026 C.4-01
ANNULAR HEAT PIPE THEORY
LAWRENCE RAD. LAB., UCID-15519, UNIV. OF CALIF., LIVERMORE, CALIF., ALSO SPACE POWER NOTE NO. 163, NOV. 17, 1966. AVAIL. TAC

28000 WEAVER C V PATRICK A J 70008 B.1-05
RANKEN W A
DEVELOPMENT AND FEASIBILITY TESTS OF ISOTHERMAL IRRADIATORS
LOS ALAMOS SCIENTIFIC LAB., NEW MEXICO, (CONF-690910 - PP. 184-96), AVAIL. TAC

28100 WERNER R W 70033 B.4-03
THE MODULE APPROACH TO BLANKET DESIGN - A VACUUM WALL FREE BLANKET USING HEAT PIPES
CALIF. UNIV., LIVERMORE. LAWRENCE RAD. LAB. AUG. 13, 1969. 38 P. REF. (UCRL-71758 CONF-690901-2) AVAIL. TAC

28200 WERNER R W CARLSON G A 67031 B.3-02
HEAT PIPE RADIATOR FOR SPACE POWER FOR A 50-MWT SPACE POWER PLANTS
LAWRENCE RAD. LAB., UCRL-50294, LIVERMORE, CALIF., JUNE 1967 AVAIL. TAC

28300 WERNER R W CARLSON G A 69044 B.3-07
HEAT PIPE RADIATOR FOR SPACE POWER PLANTS
IEEE TRANSACTIONS ON AERO. & ELEC. SYSTEMS, PAPER NO. 689068 ,NEW YORK, NEW YORK, AUG. 1968, PP. 487-503. (ALSO UCRL-71004, MAY 16, 1968. AVAIL. TAC

28400 WERNER R W 68025 C.1-03
SOME OPERATING LIMITS ON HEAT PIPES
LAWRENCE RAD. LAB., UNIV. OF CALIF., LIVERMORE, SPACE POWER NOTE NO. 293, APRIL 3, 1968. AVAIL. TAC

28401 WHITEHURST C A WHITEHOUSE G D 70083 E-07
RICHARDSON J W
THE EFFECT OF LONGITUDINAL VIBRATION ON HEAT PIPE PERFORMANCE
J. OF THE ASTRONAUTICAL SCIENCES, VOL. 17, MAR-APRIL 1970 (P.249-266) AVAIL TAC

28410 WILLIAMS R M 71007 B.2-14
A DESIGN OPTIMIZATION OF AN OUT-OF-CORE THERMIONIC CONVERTER
THERMIONIC CONVERSION SPECIALIST CONF., MIAMI, FLA., 26-29 OCT 1970 (IEEE) (NASA-TM-X-52930, E-6061), 6 P.,AVAIL.TAC

28500 WILSON A J 70007 B.1-04
ADVANCED RANKINE CYCLE PROVIDES BASIC TECHNOLOGY FOR OTHER POWER PLANTS AS WELL
AICE, INTERSOCIETY ENERGY CONVERSION ENGG. CONFERENCE, 4TH WASHINGTON DC, SEPT. 23-26, 1969, PAPER 11 C. 15 P. AVAIL. TAC

28501 WILSON W E 70040 B.5-02
AN ANALYSIS OF THE HEAT PIPE AS A HEAT SINK FOR SOLID-STATE RADIOFREQUENCY SOURCES

IEEE TRANSACTIONS ON ELECTRONIC DEVICES VOL. ED-17, NO. 11, NOV. 1970 P. 1013-1014 AVAIL. TAC

28600 WOO W 69091 D.3-01
STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS FOR ADVANCED SPACE SUITS
MATERIALS RESEARCH REPORT 1 JULY 1967- 1 SEPT. 1968, TRW SYSTEMS GROUP, REDONDO BEACH, CALIF. CONTRACT NAS23817 (NASA -CR-73271, TRW-06462-6007-R000) 72 P., AVAIL.TAC

28800 WYATT T 65016 E-01
A CONTROLLABLE HEAT PIPE EXPERIMENT FOR THE 5E-4 SATELLITE
APPLIED PHYSICS LAB., REPORT SDO-1134, JOHN HOPKINS UNIV., MARCH 1965. AVAIL. TAC

28900 YINGST T E 68024 B.5-01
HIGH POWER GRIDDED TUBES - 1968
RCA ELECTRONIC CORPORATION,LANCESTER, PA. AVAIL. TAC

29000 ZIELENBACH W J MILLER N E 70034 B.4-03
ACHIEVING UNIFORM SPECIMEN TEMPERATURES IN AN IRRADIATION CAPSULE USING HEAT PIPES
BATTELLE MEMORIAL INST., COLUMBUS, OHIO CONF.-690910-, PP. 157-64. AVAIL. TAC

29001 ZIMMERMANN P GROLL M 71010 B.3-10
HEAT PIPES IN SATELLITE TECHNOLOGY
RAUMFAHRTFORSCHUNG VOL. 14, SEPT.-OCT. 1970 P. 189-192 (IN GERMAN). AVAIL. TAC

29100 ZWICK E B 69039 B.3-06
SECONDARY POWER
SPACE/AERONAUTICS VOL. 52, JULY 69, PP. 143-148, 150. AVAIL. TAC

29200 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 65014 D.1-01
LA-3244-MS FOR PERIOD ENDING JANUARY 31, 1965., AVAIL.TAC

29300 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 65013 C.1-01
LA-3316-MS FOR PERIOD ENDING APRIL 30, 1965. AVAIL. TAC

29400 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 66018 C.1-01
LA-3370-MS FOR PERIOD ENDING JULY 31, 1965. AVAIL. TAC

29500 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 66019 C.1-01
LA-3431-MS FOR PERIOD ENDING OCTOBER 31, 1965. AVAIL. TAC

29600 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 66020 C.1-01
LA-3482-MS FOR PERIOD ENDING JANUARY 31, 1966. AVAIL. TAC

29700 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 66021 C.1-02
LA-3524-MS FOR PERIOD ENDING APRIL 30, 1966. AVAIL. TAC

29800 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 67058 E-02
LA-3625-MS FOR PERIOD ENDING OCTOBER 31, 1966. AVAIL. TAC

29900 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 67061 E-02
LA-3708-MS FOR PERIOD ENDING APRIL 30, 1967. AVAIL. TAC

30000 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART 67062 E-02
LA-3760-MS FOR PERIOD ENDING JULY 31, 1967. AVAIL. TAC

30100 ADVANCED SPACE NUCLEAR POWER PROGRAM 68022 B.4-01
QUART. RPT. JULY - SEPT. 1967. LAWRENCE RAD. LAB. CALIF.
UNIV., LIVERMORE. (UCRL-50004-67-3(1)). AVAIL. TAC

30200 APPLICATION OF HEAT PIPES TO THE SNAP-19 HEAT REJECTION 66016 B.3-01
SYSTEM
MARTIN MARIETTA CORP., REPORT NO. MND-5181. BALTIMORE,
MARYLAND. OCT. 1966. AVAIL. TAC

30400 CASCADED THERMOELECTRIC TEST GENERATOR 69013 B.2-08
PHASE 2 QUART. PROGRESS RPT., 1 DEC. 1968 - 28 FEB. 1969.
WESTINGHOUSE ELECTRIC CORP., PITTSBURGH, PA., ASTRONUCLEAR
LAB. 28 FEB. 1969 18 P., PREPARED FOR JPL (CONTRACTS NAS7-
100 JPL-952196) (NASA-CR-100775, WANL-PD (DDD)-005) AVAIL.
TAC

30500 DEMONSTRATION OF OPERATION OF ROTATING HEAT PIPES 70089 E-09
NASA LEWIS RESEARCH CENTER BULLETIN (4/16/70) AVAIL. TAC

30600 DESIGN AND FABRICATION OF ADVANCED THERMIONIC CONVERTERS 69016 B.2-09
FINAL REPORT THERMO ELECTRON ENG. CORP., WALTHAM, MASS.,
NOV. 1968, 408 P. REFS., PREPARED FOR JPL. (CONTRACTS NAS7-
100, JPL-951263) (NASA-CR-105322, TE4055-65-69) AVAIL. TAC

30700 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR 66005 B.2-02
SUMMARY TECH. REPORT 15 MARCH 1965 - 15 APRIL 1966. ERDL-998T-2, AD 634538, AVAIL. TAC

30800 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT 68033 D.1-03
THERMO ELECTRON ENG. CORP., WALTHAM, MASS.QUARTERLY REPORT, JUN 18-OCT. 12, 1967. (CONTRACTS NAS7-100. JPL-951465) (NASA-CR-91437, TE-4067-44-68) AVAIL.TAC

30900 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT 67043 D.1-01
QUARTERLY REPORT OCTOBER 1, 1966 TO JANUARY 10. 1967. THERMO ELECTRON ENGRG. CORP., REPORT NO. NASA-CR-83920 TE- 4067-76-67 QR-2. WALTHAM. MASS., JANUARY 10, 1967. AVAIL. TAC

31000 HEAT PIPE TRANSFERS HEAT WITH NEARLY UNIFORM TEMPERATURE 69006 A-03
WESTINGHOUSE R & D LETTER, MARCH 69. AVAIL. TAC

31100 HEAT PIPE - A UNIQUE AND VERSATILE DEVICE FOR HEAT TRANSFER APPLICATIONS 67004 A-02
RADIO CORP. OF AMERICA, DIRECT ENERGY CONVERSION DEPT., LANCASTER, PA., REF. 994-61S. (17 P) AVAIL TAC

31200 INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION 69002 A-03
2ND STRESA ITALY MAY 27-31, 1968 PROCEEDINGS. CONF. SPONSORED BY EUROPEAN NUCLEAR ENERGY AGENCY. LUXENBOURG EURATOM CENTER FOR INFORMATION AND DOCUMENTATION EUR NO. 4210 F, E 1969 1438 PP. IN ENGLISH AND FRENCH, AVAIL. TAC

31301 ISOTOPE KILOWATT PROGRAM 70035 B.4-03
ORNL QUART. PROC. RPT. JUNE 30, 1970. CONTRACT W-7402-ENG-26 (28P.), AVAIL. TAC

31402 LARGE TELESCOPE EXPERIMENT PROGRAM - LTEP 70037 B.5-02
VOL. 1, PART 2. 24 APRIL 1970, CONTRACT NAS8-21497. (NASA-CR-102769, RPT 9800-VOL.1-PT.2) (512P.) PERKIN - ELMER CORP., NORWALK, CONN. OPTICAL GROUP. AVAIL. TAC

31500 MADCAP 70065 D.1-05
PHASE 2 FINAL REPORT FAIRCHILD HILLER CORP., GERMANTOWN, MD. SPACE AND ELECTRONICS SYSTEMS DIV. JUN 1969 47 P. (CONTRACT NAS5-9471) (NASA-CR-109252 REPT-632-FR-090-007) AVAIL TAC

31600 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION - SANDIA LAB 67063 C.1-02

HEAT PIPE CONFERENCE
VOL. 1. SPACE ISOTOPE POWER DEPT., SANDIA LAB.. OCT. 1, 1966
AVAIL. TAC

31700 RADIOISOTOPE THERMOELECTRIC GENERATOR EMPLOYS HEAT PIPE 71039 B.2-15
WESTINGHOUSE ENGINEER, MAY 1969. AVAIL. TAC

31800 REACTOR, SYSTEM AND COMPONENT ENGINEERING 70077 D.3-02
CALIF. UNIV., LIVERMORE (LAWRENCE RAD. LAB.) UCRL-50004-67-1
PP. 47-82. AVAIL. TAC

31900 SOLAR THERMIONIC GENERATOR DEVELOPMENT 69083 D.1-05
THERMO ELECTRON ENG. CORP., WALTHAM, MASS. QUARTERLY REPORT,
MARCH 1-MAY 31,1968 CONTRACTS NAS8-100 JPL-951263. 32P.
(NASA-CR-95980 TE-4055-176-68 QR-10), AVAIL. TAC

32000 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT 68034 D.1-03
LOS ALAMOS SCIENTIFIC LABORATORY REPORT, NEW MEXICO
LA-3881-MS FOR PERIOD ENDING JANUARY 31, 1968. AVAIL. TAC

32100 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT 68052 E-04
LA-3941-MS FOR PERIOD ENDING APRIL 30, 1968. AVAIL. TAC

32200 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT 68051 E-04
LA-3986 FOR PERIOD ENDING JULY 31, 1968. AVAIL. TAC

32300 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT 69068 C.3-01
LA-4039 FOR PERIOD ENDING OCT 31, 1968. AVAIL. TAC

32400 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT 69076 C.4-03
LA-4109-MS FOR PERIOD ENDING JANUARY 31, 1969. AVAIL. TAC

32501 SPACE ELECTRIC POWER R AND D PROGRAM 70066 D.1-06
QUART. STATUS RPT., 31 JAN 1970, (CONTRACT W-7405-ENG.-36)
LA-4374, LOS ALAMOS SCIENT. LAB. (5P.). AVAIL. TAC

32602 SPACE ELECTRIC POWER R AND D PROGRAM 70016 B.2-13
QUART. RPT. APRIL 30, 1970 (PARTI) LASL CONTRACT W-7405-ENG-
36 (LA-4446) (6P.), AVAIL. TAC

32700 SPACECRAFT POWER 67029 B.3-02
JET PROPULSION LAB. CALIF. INST. OF TECH. PASADENA SPACE

PROGRAMS SUMMARY NO. 37-45 VOL. 4   30 JUNE 1967 P. 22-41
AVAIL. TAC

32800 THE DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR   66004 B.2-02
INTERIM TECHNICAL REPORT NO. 1, 15 MAR. - 15 OCT. 1965.
RADIO CORP. OF AMERICA, LANCASTER, PA., DIRECT ENERGY
CONVERSION DEPT. (1965) 76 P. REFS. (CONTRACT DA-44-009-AMC-
998(T)) (ERDL-998T-1 AD629762), AVAIL. TAC

32900 THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND   68018 B.3-03
IN ORBIT
CONTRACT NOW-62-0604-C), NASA-CR-94585, S2P-3-25, 29 APRIL
1968, 30 P. AVAIL. TAC

F.2 SUBJECT INDEX

13101	BRAYTON CYCLE VAPOR CHAMBER	(HEAT PIPE) RADIATOR STUDY=	71011	B.3-10
22601	CONCEPTUAL DESIGN OF A 2-MWT	(375KWE) NUCLEAR-ELECTRIC SPAC	71015	B.4-04
		*- * NOT INDEXED		
		*A * NOT INDEXED		
04000	IONIC CONVERTER WITH GRAPHITE	ABSORPTION CESIUM RESERVOIR WO	68014	B.2-08
29000	PERATURES IN AN IRRADIATION /	ACHIEVING UNIFORM SPECIMEN TEM	70034	B.4-03
08000	IGN AND CHARACTERISTICS OF AN	ACTINIUM FUELED THERMIONIC GEN	69022	B.2-10
26900	R/ A SHORT STUDY OF CAPILLARY	ACTION IN BOILING WATER HEAT T	70050	C.2-02
13200	ED THERMOELECTRIC / EURATOM'S	ACTIVITY IN RADIOISOTOPE POWER	67021	B.2-06
01400	PES FUNCTION ISOTHERMALLY AND	ADAPTABLY= HEAT PI	69003	A-03
12701	EPORT TASK 2 - DEVELOPMENT OF	ADSORPTION RESERVOIR= /PICAL R	70017	B.2-13
04400	=	ADVANCED CONVERTER DEVELOPMENT	67022	B.2-06
20700	URCES FOR SPACE / ANALYSIS OF	ADVANCED FAST-SPECTRUM HEAT SO	69045	B.3-07
20000	TECHNOLOGY - DEVELOPMENT OF /	ADVANCED HEAT PIPE THERMIONIC	69015	B.2-09
20001	TECHNOLOGY DEVELOPMENT OF HI/	ADVANCED HEAT PIPE THERMIONIC	70013	B.2-12
12701	TECHNOLOGY - TOPICAL REPORT /	ADVANCED HEAT PIPE THERMIONIC	70017	B.2-13
28500	S BASIC TECHNOLOGY FOR OTHER/	ADVANCED RANKINE CYCLE PROVIDE	70007	B.1-04
30000	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	67062	E-02
29400	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	66018	C.1-01
29700	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	66021	C.1-02
29900	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	67061	E-02
29800	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	67058	E-02
29600	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	66020	C.1-01
29500	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	66019	C.1-01
29200	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	65014	D.1-01
29300	ARTERLY STATUS REPORT - ART=	ADVANCED REACTOR TECHNOLOGY QU	65013	C.1-01
23820	S= HEAT PIPE TECHNOLOGY FOR	ADVANCED ROCKET THRUST CHAMBER	70025	B.3-08
30100	ROGRAM=	ADVANCED SPACE NUCLEAR POWER P	68022	B.4-01
22200	M= DEVELOPMENT OF AN	ADVANCED SPACE RADIATION SYSTE	69041	B.3-06
28600	HUMIDITY CONTROL SYSTEMS FOR	ADVANCED SPACE SUITS= /URE AND	69091	D.3-01
26100	HUMIDITY CONTROL SYSTEMS FOR	ADVANCED SPACE SUITS= /URE AND	68016	B.3-03
30600	= DESIGN AND FABRICATION OF	ADVANCED THERMIONIC CONVERTERS	69016	B.2-09
25900	PERATURE CONTROL TECHNOLOGY /	ADVANCEMENTS OF SPACE SUIT TEM	69038	B.3-06
14300	GY=	ADVANCES IN HEAT PIPE TECHNOLO	69028	B.2-12
14500		ADVANCES IN HEAT PIPE DESIGN=	67049	D.1-02
03400	PERAT/ THE SURFACE TENSION OF	AG, TL, PB, AND BI AT HIGH TEM	68007	B.1-03
05901	VEY OF COOLING TECHNIQUES FOR	AIRCRAFT ELECTRONIC EQUIPMENT=	70039	B.5-02
26300	PIPE APPLICATIONS IN NUCLEAR	AIRCRAFT PROPULSION SYSTEMS= /	70020	B.3-07
22900	ON OF HEAT PIPES TO A NUCLEAR	AIRCRAFT PROPULSION SYSTEM= /I	70024	B.3-08
22800	FOR APPLICATION TO A NUCLEAR	AIRPLANE= /NTAINING HEAT PIPES	70022	B.3-08
		*ALAMOS * NOT INDEXED		
00200	AM=	ALKALI METALS EVALUATION PROGR	67057	D.3-01
00100	AM=	ALKALI METALS EVALUATION PROGR	67056	D.3-01
02900	THE SURFACE TENSION OF THE	ALKALI METALS=	67012	B.1-02
03300	D DENSITY OF THE LIQUID EARTH	ALKALINE METALS MG, CA, SR, BA	67009	B.1-02
16400	VARIOUS HIGH-TEMP. HEAT PIPE	ALLOYS WITH WORKING FLUIDS= /F	68042	D.3-01
16300	FABRICATION AND TEST OF AN	ALUMINUM HEAT PIPES=	67032	B.3-03
24900	PERFORMANCE MAP OF AN	AMMONIA HEAT PIPE=	70088	E-09
27700	OMPATIBILITY EVALUATION OF AN	AMMONIA-ALUMIMUM-STAINLESS STE	70078	D.3-02
07900	OSTATICALLY FOCUSSED KLYSTRON	AMPLIFIERS= /SPACE BORN ELECTR	69030	B.3-04
		*AN * NOT INDEXED		
10200	PES=	ANALYSIS AND DESIGN OF HEAT PI	70068	D.1-06
14800	APOR-CHAMBER FIN-TUBE RADIAT/	ANALYSIS AND EVALUATION OF A V	65004	B.1-01
09903	OTOPIC THERMOEL/ A PARAMETRIC	ANALYSIS OF A DEEP SEA RADIOIS	70012	B.2-12

14600	FLAT CONDENSER-RADIATOR AND /	ANALYSIS OF A DOUBLE FIN-TUBE	65003	B.1-01
20700	TRUM HEAT SOURCES FOR SPACE /	ANALYSIS OF ADVANCED FAST-SPEC	69045	B.3-07
19700	RMIONIC SPACE POWER SYSTEM=	ANALYSIS OF AN OUT-OF-CORE THE	69017	B.2-09
06400	ES= THEORETICAL	ANALYSIS OF CRYOGENIC HEAT PIP	70071	D.1-07
14900	RECT-CONDENSING VAPOR-CHAMBE/	ANALYSIS OF LOW-TEMPERATURE DI	66017	C.1-01
20200	BUTIONS IN HEAT PIPE WICKS=	ANALYSIS OF TEMPERATURE DISTRI	69063	C.1-04
00300	/ IRREVERSIBLE THERMODYNAMIC	ANALYSIS OF THE AXIALLY HEATED	70060	C.3-02
28501	HEAT SINK FOR SOLID-STAT/ AN	ANALYSIS OF THE HEAT PIPE AS A	70040	B.5-02
02601	BSERVATORY HEAT PIPE - DESIGN	ANALYSIS TESTING= /RONOMICAL O	70069	D.1-06
22000	HEAT PIPE	ANALYSIS=	67002	A-01
10400	KSHOP ON HEAT PIPE DESIGN AND	ANALYSIS= WOR	68038	D.1-04
20501	VESTIGATION OF ROTATING N/ AN	ANALYTICAL AND EXPERIMENTAL IN	70043	C.1-05
25300	UDY OF SODIUM HEAT PIPES=	ANALYTICAL AND EXPERIMENTAL ST	69064	C.1-04
21800	UDY OF HEAT PIPES= AN	ANALYTICAL AND EXPERIMENTAL ST	68032	D.1-02
20800	PIPES F/ AN EXPERIMENTAL AND	ANALYTICAL STUDY OF WATER HEAT	69095	E-06
07900	VELOP THE THEORETICAL DESIGN/	ANALYTICAL STUDY PROGRAM TO DE	69030	B.3-04
		'AND ' NOT INDEXED		
19200	TI/ CONCEPT OF A GAS BUFFERED	ANNULAR HEAT PIPE FUEL IRRADIA	69049	B.4-02
27900		ANNULAR HEAT PIPE THEORY=	66026	C.4-01
19100	TI/ CONCEPT OF A GAS BUFFERED	ANNULAR HEAT-PIPE FUEL IRRADIA	69053	B.4-03
09700	A MILLIMETER WAVE PARABOLIC	ANTENNA FOR COMMUNICATIONS WIT	70027	B.3-09
07701	MICROWAVE POWER RECEIVING	ANTENNA=	71016	B.5-03
10300	ENERGY CONVERSION SYSTEMS=	APPLICABILITY OF HEAT PIPES TO	70001	A-04
21900	SUPPLIE/ HEAT PIPES AND THEIR	APPLICATION FOR NUCLEAR POWER	66011	B.2-04
01000	RMAL CONTROL= HEAT PIPE	APPLICATION FOR SPACECRAFT THE	68017	B.3-03
05600	AVIONIC	APPLICATION OF A HEAT PIPE=	69042	B.3-06
00010	FLOW PUMPING IN HE/ POSSIBLE	APPLICATION OF ELECTRO-OSMOTIC	71021	C.4-05
02500	NAP-29=	APPLICATION OF HEAT PIPES TO S	68011	B.2-07
22900	NUCLEAR AIRCRAFT PROPULSION/	APPLICATION OF HEAT PIPES TO A	70024	B.3-08
30200	HE SNAP-19 HEAT REJECTION SY/	APPLICATION OF HEAT PIPES TO T	66016	B.3-01
27101	PACECRAFT THERMAL CONTROL PR/	APPLICATION OF HEAT PIPES TO S	70026	B.3-08
26800	OLOGY TO ROCKET ENGINE COOLI/	APPLICATION OF HEAT PIPE TECHN	69035	B.3-05
27100	EDUCE CRYOGENIC BOIL-OFF IN /	APPLICATION OF HEAT PIPES TO R	69034	B.3-04
25900	ERATURE CONTROL TECHNOLOGY BY	APPLICATION OF MODIFIED HEAT P	69038	B.3-06
00800	ENT SATELLITE= HEAT PIPE	APPLICATION TO A GRAVITY-GRADI	69046	B.3-07
22800	ORE CONTAINING HEAT PIPES FOR	APPLICATION TO A NUCLEAR AIRPL	70022	B.3-08
25700	IN ELE/ HEAT PIPES AND THEIR	APPLICATION TO THERMAL CONTROL	69057	B.5-01
17000	AND VAPOR CHAMBERS AND THEIR	APPLICATION TO THERMAL CONTROL	67028	B.3-02
20700	ECTRUM HEAT SOURCES FOR SPACE	APPLICATION= /ADVANCED FAST-SP	69045	B.3-07
26300	FT PROP/ A STUDY OF HEAT PIPE	APPLICATIONS IN NUCLEAR AIRCRA	70020	B.3-07
09000	ELECTRONIC EQUIPMENT=	APPLICATIONS OF HEAT PIPES IN	69059	B.5-02
10500		APPLICATIONS OF THE HEAT PIPE=	69001	A-02
23810	= HEAT PIPE	APPLICATIONS TO SPACE VEHICLES	71013	B.3-10
25600	PE DEVELOPMENT FOR THERMIONIC	APPLICATIONS= HEAT PI	69026	B.2-11
20100	PIPE AND SOME POTENTIAL NAVAL	APPLICATIONS= THE HEAT	69009	B.1-04
06300	EVIEW OF HEAT PIPE THEORY AND	APPLICATIONS= A CRITICAL R	68002	A-02
31100	TILE DEVICE FOR HEAT TRANSFER	APPLICATIONS= /NIQUE AND VERSA	67004	A-02
21910	PIPE REACTOR FOR SPACE POWER	APPLICATIONS= /SPLIT-CORE HEAT	71014	B.4-04
12700	WICK PROPERTIES FOR HEAT PIPE	APPLICATIONS= /TERMINATION OF	69087	D.2-03
10000	SIBLE MATERIALS FOR HEAT PIPE	APPLICATIONS= /TIES OF COMPRES	69086	D.2-03
10100	SIBLE MATERIALS FOR HEAT PIPE	APPLICATIONS= /TIES OF COMPRES	68039	D.2-03
28100	VACUUM WALL FREE/ THE MODULE	APPROACH TO BLANKET DESIGN - A	70033	B.4-03
12200	LOW CATHODE LITHIUM VAPOR MPD	ARC JET= /NTS USING A 25KW HOL	69007	B.1-03
29700	OGY QUARTERLY STATUS REPORT -	ART= ADVANCED REACTOR TECHNOL	66021	C.1-02

21600	OGRAPHIC EXAMINATION OF VAPOR	BUBBLE FORMATION AS A LIMITATI	69098	E-06
19200	L IRRADIATI/ CONCEPT OF A GAS	BUFFERED ANNULAR HEAT PIPE FUE	69049	B.4-02
19100	L IRRADIATI/ CONCEPT OF A GAS	BUFFERED ANNULAR HEAT-PIPE FUE	69053	B.4-03
07000	TAINMENT OF HIGH POOL BOILING	BURNOUT HEAT FLUXES= /N THE AT	64002	C.2-01
		*BY * NOT INDEXED		
05400	PE LIFE TESTS AT 1600 DEGREES	C AND 1000 DEGREES C= HEAT PI	68055	E-05
05400	00 DEGREES C AND 1000 DEGREES	C= HEAT PIPE LIFE TESTS AT 16	68055	E-05
03300	UID EARTH ALKALINE METALS MG,	CA, SR, BA= /ENSITY OF THE LIQ	67009	B.1-02
03900	A HEAT PIPE THERMIONIC CONV/	CALORIMETRIC MEASUREMENTS WITH	69024	B.2-11
02201	CHARACTERISTICS AND LONG LIFE	CAPABILITIES OF ORGANIC FLUID	71036	E-10
17100	HEAT PIPE	CAPABILITY EXPERIMENTS=	67052	D.2-02
17300	HEAT PIPE	CAPABILITY EXPERIMENTS=	68026	C.1-03
17200	HEAT PIPE	CAPABILITY EXPERIMENTS=	67050	D.2-01
24500	F PRESSURE IN CAPILLARY MEDIA	CAPABLE OF BEING USED IN HEAT	69077	C.4-04
23401	VEMENT BY MEANS OF HEAT PIPE/	CAPACITOR ENERGY STORAGE IMPRO	71017	B.5-03
26900	TER HEAT TR/ A SHORT STUDY OF	CAPILLARY ACTION IN BOILING WA	70050	C.2-02
23000	ORIZATION COOLING SYSTEM WITH	CAPILLARY DISTRIBUTOR= / A VAP	68028	C.3-01
21401	HEATING SU/ ON THE EFFECTS OF	CAPILLARY GEOMETRY ON OPTIMAL	70044	C.1-05
04100	SURFACE WETTING THROUGH	CAPILLARY GROOVES=	70059	C.3-02
24500	NATION OF LOSS OF PRESSURE IN	CAPILLARY MEDIA CAPABLE OF BEI	69077	C.4-04
22400	ETERMINATION OF PROPERTIES OF	CAPILLARY MEDIA USEFUL IN HEAT	69088	D.2-04
17900	D TO THE HEATING SURFACE BY A	CAPILLARY POROUS BODY AT LOW P	70057	C.3-02
18900	WO-PHASE FLUID BY THERMAL AND	CAPILLARY PUMPING= /ION OF A T	62001	C.4-01
11200	VAPORIZATION HEAT TRANSFER IN	CAPILLARY WICK STRUCTURES=	69067	C.2-02
07000	DEPOSITS IN THE/ THE ROLES OF	CAPILLARY WICKING AND SURFACE	64002	C.2-01
07100	FACE WITH COOLANT SUPPLIED BY	CAPILLARY WICKING= / FOR A SUR	63001	C.2-01
06900	OPERATING CHARACTERISTICS OF	CAPILLARY-LIMITED HEAT PIPES=	67039	C.1-02
26700	IBILITY STUDY OF WATER-FILLED	CAPILLARY-PUMPED HEAT TRANSFER	66024	C.4-01
29000	EMPERATURES IN AN IRRADIATION	CAPSULE USING HEAT PIPES= /N T	70034	B.4-03
19100	AR HEAT-PIPE FUEL IRRADIATION	CAPSULE= /A GAS BUFFERED ANNUL	69053	B.4-03
19200	AR HEAT PIPE FUEL IRRADIATION	CAPSULE= /A GAS BUFFERED ANNUL	69049	B.4-02
13700	RS FOR THE ASSESSMENT OF HEAT	CARRIERS IN HEAT PIPES= /AMETE	70047	C.1-05
12100	TOR= THERMALLY	CASCADED THERMOELECTRIC GENERA	70014	B.2-13
30400	ENERATOR=	CASCADED THERMOELECTRIC TEST G	69013	B.2-08
06500	NONELECTRIC	CATHODE HEATING=	69056	B.5-01
12200	PERIMENTS USING A 25KW HOLLOW	CATHODE LITHIUM VAPOR MPD ARC	69007	B.1-03
15900	HEAT PIPES= AN ATS-E SOLAR	CELL SPACE RADIATOR UTILIZING	69037	B.3-05
14600	ADIATOR AND COMPARISON WITH A	CENTRAL FIN-TUBE RADIATOR= /-R	65003	B.1-01
23200	UDY OF FAST NEUTRON DAMAGE TO	CERAMICS= /ION ASSEMBLY FOR ST	68021	B.4-01
04000	RTER WITH GRAPHITE ABSORPTION	CESIUM RESERVOIR WORKING AT CO	68014	B.2-08
17800	FER FROM A REACTOR SURFACE TO	CESIUM VAPOR CONVERTERS= /RANS	68023	B.4-02
13101	TUDY= BRAYTON CYCLE VAPOR	CHAMBER (HEAT PIPE) RADIATOR S	71011	B.3-10
18600	VAPOR	CHAMBER FIN STUDIES=	66029	D.2-01
14700	F SPACE RADIATORS USING VAPOR	CHAMBER FINS= /ILITY STUDIES O	71040	B.3-11
17000	NOTES ON HEAT PIPES AND VAPOR	CHAMBERS AND THEIR APPLICATION	67028	B.3-02
24100	BALANC/ HEAT PIPES AND VAPOR	CHAMBERS FOR SATELLITE THERMAL	70021	B.3-08
23821	OPEL/ HEAT PIPE COOLED THRUST	CHAMBERS FOR SPACE STORABLE PR	70031	B.3-09
21100	F SPACE/ HEAT PIPES AND VAPOR	CHAMBERS FOR THERMAL CONTROL O	68019	B.3-03
16900	F SPACE/ HEAT PIPES AND VAPOR	CHAMBERS FOR THERMAL CONTROL O	67045	D.1-02
23820	GY FOR ADVANCED ROCKET THRUST	CHAMBERS= HEAT PIPE TECHNOLO	70025	B.3-08
12900	HEAT PIPE	CHANNEL FLOW DISTRIBUTIONS=	69074	C.4-03
16200	VISCOUS FLOW IN A RECTANGULAR	CHANNEL HEAT PIPE WICK=	66025	C.4-01
02201	CAPABILITIES OF OR/ OPERATING	CHARACTERISTICS AND LONG LIFE	71036	E-10
15801	NA/ A STUDY OF WIRE MESH WICK	CHARACTERISTICS IN A LONGITUDI	70074	D.2-05

HEAT PIPE TECHNOLOGY

07900	AM TO DEVELOP THE THEORETICAL	DESIGN OF SPACE BORN ELECTROST	69030	B.3-04
06800	ENGINEERING	DESIGN OF THE HEAT PIPE=	68035	D.1-03
28410	OF-CORE THERMIONIC CONVERT/ A	DESIGN OPTIMIZATION OF AN OUT-	71007	B.2-14
04001	OF-CORE NUCLEAR THERMIONIC/ A	DESIGN STUDY OF A 350 KWE OUT-	70011	B.2-12
27500	HEAT PIPE	DESIGN THEORY=	69080	D.1-04
09710	NG OF A VARIABLE CONDUCT/ THE	DESIGN, FABRICATION, AND TESTI	71028	D.1-08
14500	ADVANCES IN HEAT PIPE	DESIGN=	67049	D.1-02
16700	OPTIMUM CRYOGENIC HEAT PIPE	DESIGN=	70067	D.1-06
24200	SPACE EXPERIMENT THERMAL	DESIGN=	70023	B.3-08
05800	HEAT PIPE RADIATOR	DESIGN=	67047	D.1-02
22400	ARY MEDIA USEFUL IN HEAT PIPE	DESIGN= / PROPERTIES OF CAPILL	69088	D.2-04
13701	M HEAT TRANSPORT OF OPTIMALLY	DESIGNED HEAT PIPES= MAXIMU	70055	C.2-03
27000	ENT OF A VERSATILE SYSTEM FOR	DETAILED STUDIES ON THE PERFOR	69093	E-05
00500	COEFFICIENT FOR A HEATED HOR/	DETERMINATION OF BOILING FILM	70056	C.2-03
24500	URE IN CAPILLARY MEDIA CAPAB/	DETERMINATION OF LOSS OF PRESS	69077	C.4-04
22400	CAPILLARY MEDIA USEFUL IN H/	DETERMINATION OF PROPERTIES OF	69088	D.2-04
24600	THEORETICAL AND EXPERIMENTAL	DETERMINATION OF THE LIMITING	69079	D.1-04
10000	RTIES OF COMPRESSIBLE MATERI/	DETERMINATION OF WICKING PROPE	69086	D.2-03
12700	ES FOR HEAT PIP/ EXPERIMENTAL	DETERMINATION OF WICK PROPERTI	69087	D.2-03
10100	OF COMPRESSIBLE MATERIALS F/	DETERMINING WICKING PROPERTIES	68039	D.2-03
09910	ES FOR NITROGEN, HYDROGEN AND	DEUTERIUM= /TS IN VERTICAL TUB	71031	E-10
07900	ANALYTICAL STUDY PROGRAM TO	DEVELOP THE THEORETICAL DESIGN	69030	B.3-04
28000	STS OF ISOTHERMAL IRRADIATOR/	DEVELOPMENT AND FEASIBILITY TE	70008	B.1-05
25600	LICATIONS= HEAT PIPE	DEVELOPMENT FOR THERMIONIC APP	69026	B.2-11
32000	E ELECTRIC POWER RESEARCH AND	DEVELOPMENT LOS ALAMOS SCIENTI	68034	D.1-03
32800	HERMIONIC GENERATOR= THE	DEVELOPMENT OF A FLAME FIRED T	66004	B.2-02
30700	HERMIONIC GENERATOR=	DEVELOPMENT OF A FLAME FIRED T	66005	B.2-02
14503	IRED HEAT PIPE FOR USE W/ THE	DEVELOPMENT OF A FOSSIL FUEL F	66009	B.2-03
14502	IRED HEAT PIPE FOR USE W/ THE	DEVELOPMENT OF A FOSSIL FUEL F	66008	B.2-03
14501	IRED HEAT PIPE FOR USE W/ THE	DEVELOPMENT OF A FOSSIL FUEL F	65010	B.2-01
27000	TEM FOR DETAILED STUDIES ON /	DEVELOPMENT OF A VERSATILE SYS	69093	E-05
12701	OGY - TOPICAL REPORT TASK 2 -	DEVELOPMENT OF ADSORPTION RESE	70017	B.2-13
22200	CE RADIATION SYSTEM=	DEVELOPMENT OF AN ADVANCED SPA	69041	B.3-06
15104	ERMIONIC CONVERTER HEAT PIPE/	DEVELOPMENT OF AN INSULATED TH	66007	B.2-03
15100	ERMIONIC CONVERTER HEAT / THE	DEVELOPMENT OF AN INSULATED TH	65007	B.2-01
15101	ERMIONIC CONVERTER HEAT PIPE/	DEVELOPMENT OF AN INSULATED TH	65008	B.2-01
15102	ERMIONIC CONVERTER HEAT PIPE/	DEVELOPMENT OF AN INSULATED TH	65009	B.2-01
15103	ERMIONIC CONVERTER HEAT PIPE/	DEVELOPMENT OF AN INSULATED TH	66006	B.2-03
15300	ERMIONIC CONVERTER - HEA/ THE	DEVELOPMENT OF AN INSULATED TH	68015	B.2-08
09701	PIPES=	DEVELOPMENT OF CRYOGENIC HEAT	71025	D.1-07
20000	PIPE THERMIONIC TECHNOLOGY -	DEVELOPMENT OF HIGH VOLTAGE MO	69015	B.2-09
20001	AT PIPE THERMIONIC TECHNOLOGY	DEVELOPMENT OF HIGH VOLTAGE MO	70013	B.2-12
19900	HEAT PIPE - THERMIONIC MODU/	DEVELOPMENT OF THREE CONVERTER	69029	B.2-12
32200	E ELECTRIC POWER RESEARCH AND	DEVELOPMENT= SPAC	68051	E-04
32300	E ELECTRIC POWER RESEARCH AND	DEVELOPMENT= SPAC	69068	C.3-01
32100	E ELECTRIC POWER RESEARCH AND	DEVELOPMENT= SPAC	68052	E-04
30900	EAT PIPE THERMIONIC CONVERTER	DEVELOPMENT= H	67043	D.1-01
30800	EAT PIPE THERMIONIC CONVERTER	DEVELOPMENT= H	68033	D.1-03
31900	SOLAR THERMIONIC GENERATOR	DEVELOPMENT=	69083	D.1-05
32400	E ELECTRIC POWER RESEARCH AND	DEVELOPMENT= SPAC	69076	C.4-03
04400	ADVANCED CONVERTER	DEVELOPMENT=	67022	B.2-06
04200	EAT PIPE THERMIONIC CONVERTER	DEVELOPMENT= H	68044	E-03
31100	PIPE - A UNIQUE AND VERSATILE	DEVICE FOR HEAT TRANSFER APPLI	67004	A-02
27600	NEW WELL-DEFINED METAL VAPOR	DEVICE FOR SPECTROSCOPIC MEASU	69099	B.1-04

27300	PERATURE HEAT PIPE - A UNIQUE	DEVICE FOR THE THERMAL CONTROL	69036	B.3-05
13901	THERMIONIC CONVERTER	DEVICE=	69028	B.2-12
13900	ON-CONDENSATION HEAT TRANSFER	DEVICE= EVAPORATI	66002	A-01
16801	HEAT TRANSFER	DEVICE=	70003	A-04
02300	OF A NEW LIGHT-WEIGHT REMOVAL	DEVICE= /UBES THROUGH THE USE	68008	B.1-03
26000	TURE CONTROL= HEAT PIPE	DEVICES FOR SPACE SUIT TEMPERA	69032	B.3-04
08300	OF / HIGH THERMAL CONDUCTANCE	DEVICES UTILIZING THE BOILING	65015	E-01
01901	NENT HIGH THERMAL CONDUCTANCE	DEVICES= / TWO AND MULTI-COMPO	71001	A-04
03200	RE RANGE O/ VAPOR PRESSURE OF	DIFFERENT METALS IN THE PRESSU	67010	B.1-02
05401	HEAT PIPE THERMIONIC	DIODE POWER SYSTEM=	71008	B.2-14
19000	TS ON FLAME HEATED THERMIONIC	DIODE= TES	67025	B.2-06
15700	CE POWER EMPLOYING THERMIONIC	DIODES AND HEAT PIPE= /FOR SPA	68013	B.2-07
23800	FAST REACTOR, HEAT PIPES, AND	DIRECT CONVERTERS= /EATURES A	69051	B.4-02
12101	CONDUCTIVI/ TECHNIQUE FOR THE	DIRECT MEASUREMENT OF THERMAL	71003	B.1-05
14900	ANALYSIS OF LOW-TEMPERATURE	DIRECT-CONDENSING VAPOR-CHAMBE	66017	C.1-01
20200	KS= ANALYSIS OF TEMPERATURE	DISTRIBUTIONS IN HEAT PIPE WIC	69063	C.1-04
12900	HEAT PIPE CHANNEL FLOW	DISTRIBUTIONS=	69074	C.4-03
23000	COOLING SYSTEM WITH CAPILLARY	DISTRIBUTOR= / A VAPORIZATION	68028	C.3-01
14600	-RADIATOR AND / ANALYSIS OF A	DOUBLE FIN-TUBE FLAT CONDENSER	65003	B.1-01
05000	G HEAT PIPES= PRESSURE	DROP IN THE VAPOR PHASE OF LON	67042	C.4-02
26600	CTIVE THERMAL CONDUCTIVITY OF	DRY AND LIQUID-SATURATED SINTE	70054	C.2-03
07200	HEAT PIPE STARTUP	DYNAMICS=	68046	E-03
03300	ION AND DENSITY OF THE LIQUID	EARTH ALKALINE METALS MG, CA,	67009	B.1-02
23400	SFER IN HEAT PIPES= THE	EFFECT OF GRAVITY ON HEAT TRAN	70063	C.4-04
28401	ON ON HEAT PIPE PERFORMA/ THE	EFFECT OF LONGITUDINAL VIBRATI	70083	E-07
05801	EAT PIPES=	EFFECT OF MAGNETIC FIELDS ON H	70045	C.1-05
20600	THE OPERATION OF LOW TEMPERA/	EFFECT OF NUCLEATE BOILING ON	69069	C.3-01
08200	PE PERFORMANCE= THE	EFFECT OF VIBRATION ON HEAT PI	68043	E-02
17700	OPERATION OF A LONGITUD/ THE	EFFECT OF WICK GEOMETRY ON THE	70072	D.2-04
26600	OF DRY AND LIQUID-SATURATED/	EFFECTIVE THERMAL CONDUCTIVITY	70054	C.2-03
06401	A STUDY OF NONCONDENSIBLE	EFFECTS IN A HEAT PIPE=	71020	C.4-05
19501	VAPOR COMPRESSIBILITY	EFFECTS IN HEAT PIPES=	70062	C.4-04
21401	ON OPTIMAL HEATING SU/ ON THE	EFFECTS OF CAPILLARY GEOMETRY	70044	C.1-05
00900	S ON HEAT PIPE OPTIMIZATION=	EFFECTS OF CONDENSER PARAMETER	67040	C.3-01
19510	IC VELOCITY LIMIT IN SODIUM /	EFFECTS OF FRICTION ON THE SON	71022	C.4-05
32602	= SPACE	ELECTRIC POWER R AND D PROGRAM	70016	B.2-13
32501	= SPACE	ELECTRIC POWER R AND D PROGRAM	70066	D.1-06
32000	VELOPMENT LOS ALAMOS S/ SPACE	ELECTRIC POWER RESEARCH AND DE	68034	D.1-03
32100	VELOPMENT= SPACE	ELECTRIC POWER RESEARCH AND DE	68052	E-04
32300	VELOPMENT= SPACE	ELECTRIC POWER RESEARCH AND DE	69068	C.3-01
32400	VELOPMENT= SPACE	ELECTRIC POWER RESEARCH AND DE	69076	C.4-03
32200	VELOPMENT= SPACE	ELECTRIC POWER RESEARCH AND DE	68051	E-04
04004	USE OF HEAT PIPES FOR	ELECTRICAL ISOLATION=	71005	B.2-14
31200	ONAL CONFERENCE ON THERMIONIC	ELECTRICAL POWER GENERATION= /	69002	A-03
13600	EOUS-CORE REACTOR CONCEPT FOR	ELECTRICAL POWER GENERATION= /	70018	B.2-13
02000	PE FOR DEPRESSED COLLECTO/ AN	ELECTRICALLY INSULATED HEAT PI	69054	B.5-01
00010	N HE/ POSSIBLE APPLICATION OF	ELECTRO-OSMOTIC FLOW PUMPING I	71021	C.4-05
09901	HEAT PIPE STUDIES AT THERMO	ELECTRON CORPORATION=	69018	B.2-09
02100	HEAT PIPE DESIGN FOR	ELECTRON TUBE COOLING=	69058	B.5-02
06600	LE= COOLING OF A HIGH POWER	ELECTRON TUBE IN A SPACE VEHIC	69055	B.5-01
05901	OLING TECHNIQUES FOR AIRCRAFT	ELECTRONIC EQUIPMENT= /Y OF CO	70039	B.5-02
09000	APPLICATIONS OF HEAT PIPES IN	ELECTRONIC EQUIPMENT=	69059	B.5-02
25700	ICATION TO THERMAL CONTROL IN	ELECTRONIC EQUIPMENT= /IR APPL	69057	B.5-01
07900	ORETICAL DESIGN OF SPACE BORN	ELECTROSTATICALLY FOCUSSED KLY	69030	B.3-04

08100	T PIPE M/ TOTAL HEMISPHERICAL	EMISSIVITY MEASUREMENTS BY HEA	68005	B.1-02
03600	R OF A HEAT PIPE OPERATING AT	EMITTER TEMPERATURE= / TRANSFE	66015	B.3-01
09903	OPIC THERMOELECTRIC GENERATOR	EMPLOYING A HEAT PIPE= /IOISOT	70012	B.2-12
15800	IC SPACE POWER SYSTEM CONCEPT	EMPLOYING HEAT PIPES= /HERMION	68010	B.2-07
26500	N OF GAS TURBINE REGENERATORS	EMPLOYING HEAT PIPES= /ALUATIO	68004	B.1-02
15700	ACTOR CONCEPT FOR SPACE POWER	EMPLOYING THERMIONIC DIODES AN	68013	B.2-07
23900	HERMIONIC REACTORS=	EMPLOYMENT OF HEAT PIPES FOR T	66010	B.2-03
31700	TOPE THERMOELECTRIC GENERATOR	EMPLOYS HEAT PIPE= RADIOISO	71039	B.2-15
31600	PROCEEDINGS OF JOINT ATOMIC	ENERGY COMMISSION - SANDIA LAB	67063	C.1-02
10300	PPLICABILITY OF HEAT PIPES TO	ENERGY CONVERSION SYSTEMS= A	70001	A-04
12800	EE KW FLAME HEATED THERMIONIC	ENERGY CONVERTER= THR	66012	B.2-04
19300	NUCLEAR-THERMIONIC	ENERGY CONVERTER=	66013	B.2-04
09500	FOSSIL-FUEL-FIRED THERMIONIC	ENERGY CONVERTERS= REVIEW OF	67015	B.2-04
14503	PIPE FOR USE WITH THERMIONIC	ENERGY CONVERTERS= /FIRED HEAT	66009	B.2-03
14502	PIPE FOR USE WITH THERMIONIC	ENERGY CONVERTERS= /FIRED HEAT	66008	B.2-03
14501	PIPE FOR USE WITH THERMIONIC	ENERGY CONVERTERS= /FIRED HEAT	65010	B.2-01
16800	RCA TEST THERMAL	ENERGY PIPE=	66032	E-01
23401	MEANS OF HEAT PIPE/ CAPACITOR	ENERGY STORAGE IMPROVEMENT BY	71017	B.5-03
21400	= LIMITATIONS OF	ENERGY TRANSPORT IN HEAT PIPES	70049	C.1-06
26800	EAT PIPE TECHNOLOGY TO ROCKET	ENGINE COOLING= /LICATION OF H	69035	B.3-05
07600	TED CRYOGENIC ISOTOPE COOLING	ENGINE SYSTEM - ICICLE FEASIBI	70009	B.1-05
07501	TED CRYOGENIC ISOTOPE COOLING	ENGINE SYSTEM= /ICLE - INTEGRA	70010	B.1-05
06800	PIPE=	ENGINEERING DESIGN OF THE HEAT	68035	D.1-03
07300	ES= STATUS OF THE	ENGINEERING THEORY OF HEAT PIP	67034	C.1-02
31800	REACTOR, SYSTEM AND COMPONENT	ENGINEERING=	70077	D.3-02
08600	T PIPE PERFORMANCE IN A SPACE	ENVIRONMENT= HEA	68045	E-03
09710	BLE CONDUCTANCE HEAT PIPE FOR	EQUIPMENT THERMAL CONTROL= /IA	71028	D.1-08
09000	S OF HEAT PIPES IN ELECTRONIC	EQUIPMENT= APPLICATION	69059	B.5-02
25700	THERMAL CONTROL IN ELECTRONIC	EQUIPMENT= /IR APPLICATION TO	69057	B.5-01
05901	IQUES FOR AIRCRAFT ELECTRONIC	EQUIPMENT= /Y OF COOLING TECHN	70039	B.5-02
23100	NS= SURVEY OF LOS ALAMOS AND	EURATOM HEAT PIPE INVESTIGATIO	66001	A-01
13200	TOPE POWERED THERMOELECTRIC /	EURATOM'S ACTIVITY IN RADIOISO	67021	B.2-06
04700	HEAT PIPE RESEARCH IN	EUROPE=	69060	C.1-03
04800	RMIONIC CONVERTER RESEARCH IN	EUROPE= HEAT PIPE THE	69025	B.2-11
04010	FEEDBACK CONTROLLED/ STUDY TO	EVALUATE THE FEASIBILITY OF A	71024	D.1-07
14800	FIN-TUBE RADIAT/ ANALYSIS AND	EVALUATION OF A VAPOR-CHAMBER	65004	B.1-01
27700	MUM-STAINLESS / COMPATIBILITY	EVALUATION OF AN AMMONIA-ALUMI	70078	D.3-02
15200	PERATURE CONTRO/ EXPERIMENTAL	EVALUATION OF AN AUTOMATIC TEM	71043	B.1-05
17901	HERMIONIC CO/ FABRICATION AND	EVALUATION OF AN OUT-OF-CORE T	71006	B.2-14
26500	NERATORS EMPLOYI/ PRELIMINARY	EVALUATION OF GAS TURBINE REGE	68004	B.1-02
09800	PIPE PERFORMANCE=	EVALUATION OF THEORETICAL HEAT	67037	C.1-02
00200	ALKALI METALS	EVALUATION PROGRAM=	67057	D.3-01
00100	ALKALI METALS	EVALUATION PROGRAM=	67056	D.3-01
18000	NAMIC BOUNDARY CONDITIONS FOR	EVAPORATION AND CONDENSATION= /	60001	C.3-01
23500	MAXIMUM POWER DENSITY AT THE	EVAPORATION GAINED FROM HEAT P	69066	C.2-01
01600	LIQUID-VAPOR INTERACTION AND	EVAPORATION IN HEAT PIPES=	69072	C.4-02
13900	TRANSFER DEVICE=	EVAPORATION-CONDENSATION HEAT	66002	A-01
10800	ANISM OF HEAT TRANSFER IN THE	EVAPORATOR ZONE OF A HEAT PIPE	70061	C.3-03
08001	ES CONTAINING POTASSIUM=	EXAMINATION OF NICKEL HEAT PIP	71034	E-10
21600	RMATION/ NEUTRON RADIOGRAPHIC	EXAMINATION OF VAPOR BUBBLE FO	69098	E-06
17900	LIVERE/ INVESTIGATION OF HEAT	EXCHANGE WITH BOILING WATER DE	70057	C.3-02
28800	ITE/ A CONTROLLABLE HEAT PIPE	EXPERIMENT FOR THE SE-4 SATELL	65016	E-01
31402	LARGE TELESCOPE	EXPERIMENT PROGRAM - LTEP=	70037	B.5-02
24200	SPACE	EXPERIMENT THERMAL DESIGN=	70023	B.3-08

13500	SHAFT FOR TRANS/ THE ROTATING	HEAT PIPE	- A WICKLESS HOLLOW	69081	D.1-04
02601	ITAL ASTRONOMICAL OBSERVATORY	HEAT PIPE	- DESIGN ANALYSIS TE	70069	D.1-06
09600	HEAT TRANSFER=	HEAT PIPE	- SPACE SPINOFF FOR	70005	A-04
19900	EVELOPMENT OF THREE CONVERTER	HEAT PIPE	- THERMIONIC MODULE=	69029	B.2-12
16400	IBILITY OF VARIOUS HIGH-TEMP.	HEAT PIPE	ALLOYS WITH WORKING	68042	D.3-01
22000		HEAT PIPE	ANALYSIS=	67002	A-01
25000	THE	HEAT PIPE	AND ITS OPERATION=	69005	A-03
20100	AVAL APPLICATIONS= THE	HEAT PIPE	AND SOME POTENTIAL N	69009	B.1-04
25100	PERFORMANCE MAP OF THE WATER	HEAT PIPE	AND THE PHENOMENON O	69097	E-06
21700	FOR COOLING GAS TURBINE/ THE	HEAT PIPE	AND THE THERMOSYPHON	67008	B.1-01
23810	E VEHICLES=	HEAT PIPE	APPLICATIONS TO SPAC	71013	B.3-10
26300	EAR AIRCRAFT PROP/ A STUDY OF	HEAT PIPE	APPLICATIONS IN NUCL	70020	B.3-07
10100	OF COMPRESSIBLE MATERIALS FOR	HEAT PIPE	APPLICATIONS= /TIES	68039	D.2-03
12700	NATION OF WICK PROPERTIES FOR	HEAT PIPE	APPLICATIONS= /TERMI	69087	D.2-03
10000	OF COMPRESSIBLE MATERIALS FOR	HEAT PIPE	APPLICATIONS= /TIES	69086	D.2-03
00800	VITY-GRADIENT SATELLITE=	HEAT PIPE	APPLICATION TO A GRA	69046	B.3-07
01000	ECRAFT THERMAL CONTROL=	HEAT PIPE	APPLICATION FOR SPAC	68017	B.3-03
28501	OLID-STAT/ AN ANALYSIS OF THE	HEAT PIPE	AS A HEAT SINK FOR S	70040	B.5-02
15103	NSULATED THERMIONIC CONVERTER	HEAT PIPE	ASSEMBLY= /T OF AN I	66006	B.2-03
15101	NSULATED THERMIONIC CONVERTER	HEAT PIPE	ASSEMBLY= /T OF AN I	65008	B.2-01
15104	NSULATED THERMIONIC CONVERTER	HEAT PIPE	ASSEMBLY= /T OF AN I	66007	B.2-03
15300	ULATED THERMIONIC CONVERTER -	HEAT PIPE	ASSEMBLY= /OF AN INS	68015	B.2-08
15102	NSULATED THERMIONIC CONVERTER	HEAT PIPE	ASSEMBLY= /T OF AN I	65009	B.2-01
15100	NSULATED THERMIONIC CONVERTER	HEAT PIPE	ASSEMBLY= /T OF AN I	65007	B.2-01
17100	TS=	HEAT PIPE	CAPABILITY EXPERIMEN	67052	D.2-02
17300	TS=	HEAT PIPE	CAPABILITY EXPERIMEN	68026	C.1-03
17200	TS=	HEAT PIPE	CAPABILITY EXPERIMEN	67050	D.2-01
12900	UTIONS=	HEAT PIPE	CHANNEL FLOW DISTRIB	69074	C.4-03
31600	NERGY COMMISSION - SANDIA LAB	HEAT PIPE	CONFERENCE= /TOMIC E	67063	C.1-02
09900	TWO PIECE	HEAT PIPE	CONVERTER=	68006	B.1-03
23821	RS FOR SPACE STORABLE PROPEL/	HEAT PIPE	COOLED THRUST CHAMBE	70031	B.3-09
10400	WORKSHOP ON	HEAT PIPE	DESIGN AND ANALYSIS=	68038	D.1-04
17500	S=	HEAT PIPE	DESIGN CONSIDERATION	69084	D.1-05
02100	TUBE COOLING=	HEAT PIPE	DESIGN FOR ELECTRON	69058	B.5-02
12300		HEAT PIPE	DESIGN MANUAL=	68037	D.1-03
27500		HEAT PIPE	DESIGN THEORY=	69080	D.1-04
16700	OPTIMUM CRYOGENIC	HEAT PIPE	DESIGN=	70067	D.1-06
14500	ADVANCES IN	HEAT PIPE	DESIGN=	67049	D.1-02
22400	OF CAPILLARY MEDIA USEFUL IN	HEAT PIPE	DESIGN= / PROPERTIES	69088	D.2-04
25600	MIONIC APPLICATIONS=	HEAT PIPE	DEVELOPMENT FOR THER	69026	B.2-11
26000	IT TEMPERATURE CONTROL=	HEAT PIPE	DEVICES FOR SPACE SU	69032	B.3-04
28800	E-4 SATELLITE/ A CONTROLLABLE	HEAT PIPE	EXPERIMENT FOR THE S	65016	E-01
23500	T THE EVAPORATION GAINED FROM	HEAT PIPE	EXPERIMENTS= /SITY A	69066	C.2-01
25601	THE	HEAT PIPE	EXPERIMENT=	70002	A-04
14400		HEAT PIPE	EXPERIMENTS=	66033	E-01
08800	ORBITAL	HEAT PIPE	EXPERIMENT=	67030	B.3-02
17710	A VARIABLE CONDUCTANCE	HEAT PIPE	FLIGHT EXPERIMENT=	71038	E-11
08400	MERCURY AS A	HEAT PIPE	FLUID=	70076	D.3-02
02000	TO/ AN ELECTRICALLY INSULATED	HEAT PIPE	FOR DEPRESSED COLLEC	69054	B.5-01
09710	ING OF A VARIABLE CONDUCTANCE	HEAT PIPE	FOR EQUIPMENT THERMA	71028	D.1-08
06700	AL CONTROL= A CONTINUOUS	HEAT PIPE	FOR SPACECRAFT THERM	68036	D.1-03
14502	OPMENT OF A FOSSIL FUEL FIRED	HEAT PIPE	FOR USE WITH THERMIO	66008	B.2-03
14501	OPMENT OF A FOSSIL FUEL FIRED	HEAT PIPE	FOR USE WITH THERMIO	65010	B.2-01
14503	OPMENT OF A FOSSIL FUEL FIRED	HEAT PIPE	FOR USE WITH THERMIO	66009	B.2-03

19200	EPT OF A GAS BUFFERED ANNULAR	HEAT PIPE	FUEL IRRADIATION CAP	69049	B.4-02
26400	TORS=	HEAT PIPE	GAS TURBINE REGENERA	69008	B.1-03
23100	VEY OF LOS ALAMOS AND EURATOM	HEAT PIPE	INVESTIGATIONS= SUR	66001	A-01
05400	EGREES C AND 1000 DEGREES C=	HEAT PIPE	LIFE TESTS AT 1600 D	68055	E-05
08100	AL EMISSIVITY MEASUREMENTS BY	HEAT PIPE	METHOD= /HEMISPHERIC	68005	B.1-02
21300	- THREADED ARTERY HEAT PIPE=	HEAT PIPE	OF NEW CONSTRUCTION	70048	C.1-06
03600	TEMPERAT/ HEAT TRANSFER OF A	HEAT PIPE	OPERATING AT EMITTER	66015	B.3-01
06200		HEAT PIPE	OPTIMIZATION=	67048	D.1-02
00900	TS OF CONDENSER PARAMETERS ON	HEAT PIPE	OPTIMIZATION= EFFEC	67040	C.3-01
27600	FINED METAL VAPOR DEVICE FOR/	HEAT PIPE	OVEN - A NEW WELL-DE	69099	B.1-04
16001	PRELIMINARY PROGRAM PLAN	HEAT PIPE	PARAMETRIC DATA=	70081	E-07
09920	TIFICIAL GRAVITY FIELD=	HEAT PIPE	PERFORMANCE IN AN AR	71035	E-10
08200	THE EFFECT OF VIBRATION ON	HEAT PIPE	PERFORMANCE=	68043	E-02
09800	EVALUATION OF THEORETICAL	HEAT PIPE	PERFORMANCE=	67037	C.1-02
08600	CE ENVIRONMENT=	HEAT PIPE	PERFORMANCE IN A SPA	68045	E-03
08700	O-G GRAVITY FIELD=	HEAT PIPE	PERFORMANCE IN A ZER	68050	E-04
17600	ULTIMATE	HEAT PIPE	PERFORMANCE=	69073	C.4-03
21601	PHIC STUDY OF LIMITING PLANAR	HEAT PIPE	PERFORMANCE= /DIOGRA	70084	E-08
28401	OF LONGITUDINAL VIBRATION ON	HEAT PIPE	PERFORMANCE= /EFFECT	70083	E-07
21600	ION AS A LIMITATION ON PLANAR	HEAT PIPE	PERFORMANCE= /FORMAT	69098	E-06
00301	=	HEAT PIPE	PRINCIPLE PUT TO USE	71004	B.1-05
05800		HEAT PIPE	RADIATOR DESIGN=	67047	D.1-02
28200	OWER FOR A 50-MWT SPACE POWE/	HEAT PIPE	RADIATOR FOR SPACE P	67031	B.3-02
28300	OWER PLANTS=	HEAT PIPE	RADIATOR FOR SPACE P	69044	B.3-07
21910	WER APPLICATION/ A SPLIT-CORE	HEAT PIPE	REACTOR FOR SPACE PO	71014	B.4-04
04700		HEAT PIPE	RESEARCH IN EUROPE=	69060	C.1-03
22300	LOW-TEMPERATURE	HEAT PIPE	RESEARCH PROGRAM=	69094	E-05
22500	LOW TEMPERATURE	HEAT PIPE	RESEARCH=	68054	E-05
01300	THERMIONIC	HEAT PIPE	SPACE POWER CONCEPT=	68012	B.2-07
27400	DESIGN OF A 50000 WATT	HEAT PIPE	SPACE RADIATOR=	69048	B.3-07
07200		HEAT PIPE	STARTUP DYNAMICS=	68046	E-03
26501	REEXAMINATION OF	HEAT PIPE	STARTUP=	71029	E-09
09901	ECTRON CORPORATION=	HEAT PIPE	STUDIES AT THERMO EL	69018	B.2-09
15400	RMANCE IN TEST AN/ THE GEOS-2	HEAT PIPE	SYSTEM AND ITS PERFO	70080	E-07
32900	RMANCE IN TEST AN/ THE GEOS-2	HEAT PIPE	SYSTEM AND ITS PERFO	68018	B.3-03
25110	T THERMAL CONTROL=	HEAT PIPE	SYSTEM FOR SPACECRAF	71012	B.3-10
15500	PERFORMANCE OF THE GEOS-2	HEAT PIPE	SYSTEM=	69040	B.3-06
25500	S ON A THERMIONIC-CONVERTER -	HEAT PIPE	SYSTEM= /MEASUREMENT	67060	E-02
16600	OSION STUDIES OF LIQUID METAL	HEAT PIPE	SYSTEMS AT 1000 TO 1	70075	D.3-02
06410	RUCTURES= CIRCUMFERENTIAL	HEAT PIPE	SYSTEMS FOR LARGE ST	71023	D.1-07
14300	ADVANCES IN	HEAT PIPE	TECHNOLOGY=	69028	B.2-12
26800	ENGINE COOLI/ APPLICATION OF	HEAT PIPE	TECHNOLOGY TO ROCKET	69035	B.3-05
23820	CED ROCKET THRUST CHAMBERS=	HEAT PIPE	TECHNOLOGY FOR ADVAN	70025	B.3-08
06300	ONS= A CRITICAL REVIEW OF	HEAT PIPE	THEORY AND APPLICATI	68002	A-02
27900	ANNULAR	HEAT PIPE	THEORY=	66026	C.4-01
30800	DEVELOPMENT=	HEAT PIPE	THERMIONIC CONVERTER	68033	D.1-03
30900	DEVELOPMENT=	HEAT PIPE	THERMIONIC CONVERTER	67043	D.1-01
22100	ONCEPT=	HEAT PIPE	THERMIONIC REACTOR C	67026	B.2-07
04200	DEVELOPMENT=	HEAT PIPE	THERMIONIC CONVERTER	68044	E-03
04800	RESEARCH IN EUROPE=	HEAT PIPE	THERMIONIC CONVERTER	69025	B.2-11
04900	S FOR SPACE / OPTIMIZATION OF	HEAT PIPE	THERMIONIC CONVERTER	66003	B.2-02
05100	S FOR SPACE RE/ PROTOTYPES OF	HEAT PIPE	THERMIONIC CONVERTER	65011	B.2-02
05401	ER SYSTEM=	HEAT PIPE	THERMIONIC DIODE POW	71008	B.2-14
01900	ER CONCEPT= AN OUT-OF-PILE	HEAT PIPE	THERMIONIC SPACE-POW	67018	B.2-05

03500	RAPHITE RESERVOIR SYSTEM IN A	HEAT PIPE	THERMIONIC CONVERTER	67023	B.2-06
03900	ORIMETRIC MEASUREMENTS WITH A	HEAT PIPE	THERMIONIC CONVERTER	69024	B.2-11
04000	WITH GRAPHITE ABSORPTION CE/	HEAT PIPE	THERMIONIC CONVERTER	68014	B.2-08
12000	ONCEPT= A	HEAT PIPE	THERMIONIC REACTOR C	69020	B.2-10
20001	Y DEVELOPMENT OF HI/ ADVANCED	HEAT PIPE	THERMIONIC TECHNOLOG	70013	B.2-12
12701	Y - TOPICAL REPORT / ADVANCED	HEAT PIPE	THERMIONIC TECHNOLOG	70017	B.2-13
20000	Y - DEVELOPMENT OF / ADVANCED	HEAT PIPE	THERMIONIC TECHNOLOG	69015	B.2-09
31000	NEARLY UNIFORM TEMPERATURE=	HEAT PIPE	TRANSFERS HEAT WITH	69006	A-03
16200	FLOW IN A RECTANGULAR CHANNEL	HEAT PIPE	WICK= VISCOUS	66025	C.4-01
18500	TRANSPORT PROPERTIES OF SOME	HEAT PIPE	WICKING MATERIALS= /	69090	D.2-04
18400	D HEAT TRANSFER PROPERTIES OF	HEAT PIPE	WICKING MATERIALS= /	71044	D.2-06
20200	TEMPERATURE DISTRIBUTIONS IN	HEAT PIPE	WICKS= ANALYSIS OF	69063	C.1-04
16110	F HEAT AND MASS TRANSFER IN A	HEAT PIPE	WITH A SODIUM COOLAN	71033	E-10
09902	ING PHENOMENON IN A CRYOGENIC	HEAT PIPE	WITH VERTICAL COUNTE	70064	C.4-05
03800	R MEASUREMENTS USING A SODIUM	HEAT PIPE	WORKING AT LOW VAPOR	68027	C.2-01
06800	ENGINEERING DESIGN OF THE	HEAT PIPE=		68035	D.1-03
02700	UCTION AND TEST OF A FLEXIBLE	HEAT PIPE=	CONSTR	70086	E-08
01100	MOMENTUM FLUX AND DESIGN OF A	HEAT PIPE=	TWO-PHASE	66023	C.4-01
05600	AVIONIC APPLICATION OF A	HEAT PIPE=		69042	B.3-06
05500	AN AVIONIC	HEAT PIPE=		69043	B.3-07
07800	THE	HEAT PIPE=		68003	A-02
04401	DESIGN AND OPERATION OF A	HEAT PIPE=		68053	E-04
06000	PERFORMANCE OF A WICK-LIMITED	HEAT PIPE=		69089	D.2-04
06401	F NONCONDENSIBLE EFFECTS IN A	HEAT PIPE=	A STUDY O	71020	C.4-05
05900	OPERATING LIMITS OF THE	HEAT PIPE=		67035	C.1-02
00700	ON THE PERFORMENCE OF A	HEAT PIPE=		66022	C.2-01
20900	THE PERFORMANCE OF A SODIUM	HEAT PIPE=		70082	E-07
18201	THERMOELECTRIC - BIOMEDICAL	HEAT PIPE=		70019	B.2-14
10700	THE	HEAT PIPE=		67006	A-02
08500	SATELLITE	HEAT PIPE=		65012	B.3-01
09400	THE	HEAT PIPE=		68001	A-02
10500	APPLICATIONS OF THE	HEAT PIPE=		69001	A-02
15600	CRYOGENIC	HEAT PIPE=		67044	D.1-01
12400	OPTIMIZATION OF A GROOVED	HEAT PIPE=		67046	D.1-02
15910	THERMAL SCALE MODELING OF A	HEAT PIPE=		71018	C.1-06
10600	EXPERIMENTS WITH A TWO-FLUID	HEAT PIPE=		69096	E-06
16000	THERMAL SCALE MODELING OF A	HEAT PIPE=		70046	C.1-05
17400	HIGH PERFORMANCE	HEAT PIPE=		68040	D.2-03
22700	THE	HEAT PIPE=		67005	A-02
24900	PERFORMANCE MAP OF AN AMMONIA	HEAT PIPE=		70088	E-09
26200	THE	HEAT PIPE=		70004	A-04
31700	RMOELECTRIC GENERATOR EMPLOYS	HEAT PIPE=	RADIOISOTOPE THE	71039	B.2-15
10900	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	69065	C.1-04
11300	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	67059	E-02
11400	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	67041	C.4-02
11500	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	67036	C.1-02
11800	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	68049	E-03
11100	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	70051	C.2-02
11600	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	68048	E-03
11700	RATING CHARACTERISTICS OF THE	HEAT PIPE=	STUDY OF THE OPE	68029	C.3-01
21300	ONSTRUCTION - THREADED ARTERY	HEAT PIPE=	HEAT PIPE OF NEW C	70048	C.1-06
27700	ONIA-ALUMIMUM-STAINLESS STEEL	HEAT PIPE=	/ALUATION OF AN AMM	70078	D.3-02
15200	OMATIC TEMPERATURE CONTROLLED	HEAT PIPE=	/ALUATION OF AN AUT	71043	B.1-05
23401	ORAGE IMPROVEMENT BY MEANS OF	HEAT PIPE=	/APACITOR ENERGY ST	71017	B.5-03

09200	OR VELOCITY LIMIT IN A SODIUM	HEAT PIPE=	/ENTAL STUDY OF VAP	69075	C.4-03
15700	PLOYING THERMIONIC DIODES AND	HEAT PIPE=	/FOR SPACE POWER EM	68013	B.2-07
17700	E OPERATION OF A LONGITUDINAL	HEAT PIPE=	/ICK GEOMETRY ON TH	70072	D.2-04
09903	LECTRIC GENERATOR EMPLOYING A	HEAT PIPE=	/IOISOTOPIC THERMOE	70012	B.2-12
15801	ACTERISTICS IN A LONGITUDINAL	HEAT PIPE=	/IRE MESH WICK CHAR	70074	D.2-05
00300	NALYSIS OF THE AXIALLY HEATED	HEAT PIPE=	/LE THERMODYNAMIC A	70060	C.3-02
12101	TEMPERATURES BY THE USE OF A	HEAT PIPE=	/NDUCTIVITY AT HIGH	71003	B.1-05
10800	R IN THE EVAPORATOR ZONE OF A	HEAT PIPE=	/SM OF HEAT TRANSFE	70061	C.3-03
07901	RATION OF A ROTATING WICKLESS	HEAT PIPE=	/TAL DESIGN AND OPE	70085	E-08
04010	NTROLLED VARIABLE CONDUCTANCE	HEAT PIPE=	/Y OF A FEEDBACK CO	71024	D.1-07
09100	L CIRCUITRY=	HEAT PIPES	- A COOL WAY TO COO	70038	B.5-02
21200	RON ULTRA-VACUUM SYSTEM USING	HEAT PIPES	AND METAL CONDUCTOR	69011	B.1-04
25700	ON TO THERMAL CONTROL IN ELE/	HEAT PIPES	AND THEIR APPLICATI	69057	B.5-01
21900	ON FOR NUCLEAR POWER SUPPLIE/	HEAT PIPES	AND THEIR APPLICATI	66011	B.2-04
24100	FOR SATELLITE THERMAL BALANC/	HEAT PIPES	AND VAPOR CHAMBERS	70021	B.3-08
16900	FOR THERMAL CONTROL OF SPACE/	HEAT PIPES	AND VAPOR CHAMBERS	67045	D.1-02
17000	AND THEIR APPLICATI/ NOTES ON	HEAT PIPES	AND VAPOR CHAMBERS	67028	B.3-02
21100	FOR THERMAL CONTROL OF SPACE/	HEAT PIPES	AND VAPOR CHAMBERS	68019	B.3-03
01500	IMINARY RESULTS OF A STUDY OF	HEAT PIPES	AT HIGH TEMPERATURE	69061	C.1-03
07500	ON THEORY AND EXPERIMENTS ON	HEAT PIPES	AT LOS ALAMOS= /ORT	66031	E-01
17910	MENTAL PERFORMANCE OF GROOVED	HEAT PIPES	AT MODERATE TEMPERA	71037	E-11
08001	M= EXAMINATION OF NICKEL	HEAT PIPES	CONTAINING POTASSIU	71034	E-10
22800	OF A REACTOR CORE CONTAINING	HEAT PIPES	FOR APPLICATION TO	70022	B.3-08
04004	ATION= USE OF	HEAT PIPES	FOR ELECTRICAL ISOL	71005	B.2-14
20800	AND ANALYTICAL STUDY OF WATER	HEAT PIPES	FOR MODERATE TEMPER	69095	E-06
25800	ERATURE CONTROL=	HEAT PIPES	FOR SPACE SUIT TEMP	69047	B.3-07
02600	TROL=	HEAT PIPES	FOR TEMPERATURE CON	69010	B.1-04
25200	ERTER WITH ISOTOPIC FUEL=	HEAT PIPES	FOR THERMIONIC CONV	67020	B.2-05
23900	TORS= EMPLOYMENT OF	HEAT PIPES	FOR THERMIONIC REAC	66010	B.2-03
01400	LY AND ADAPTABLY=	HEAT PIPES	FUNCTION ISOTHERMAL	69003	A-03
09000	MENT= APPLICATIONS OF	HEAT PIPES	IN ELECTRONIC EQUIP	69059	B.5-02
29001	LOGY=	HEAT PIPES	IN SATELLITE TECHNO	71010	B.3-10
19500	THEORETICAL INVESTIGATION OF	HEAT PIPES	OPERATING AT LOW VA	69071	C.4-02
16101	TIONS IN SINGLE AND TWO FLUID	HEAT PIPES	OPERATING IN THE GR	71030	E-09
22900	FT PROPULSION/ APPLICATION OF	HEAT PIPES	TO A NUCLEAR AIRCRA	70024	B.3-08
02200	ERATURE IN SY/ UNIDIRECTIONAL	HEAT PIPES	TO CONTROL TWT TEMP	70030	B.3-09
10300	N SYSTEMS= APPLICABILITY OF	HEAT PIPES	TO ENERGY CONVERSIO	70001	A-04
27100	BOIL-OFF IN / APPLICATION OF	HEAT PIPES	TO REDUCE CRYOGENIC	69034	B.3-04
02500	APPLICATION OF	HEAT PIPES	TO SNAP-29=	68011	B.2-07
27101	AL CONTROL PR/ APPLICATION OF	HEAT PIPES	TO SPACECRAFT THERM	70026	B.3-08
30200	REJECTION SY/ APPLICATION OF	HEAT PIPES	TO THE SNAP-19 HEAT	66016	B.3-01
04600	N IN HIGH TEMPERATURE LITHIUM	HEAT PIPES	WITH NIOBIUM-1ZIRCO	70079	D.3-03
23800	CEPT FEATURES A FAST REACTOR,	HEAT PIPES,	AND DIRECT CONVERT	69051	B.4-02
24400	AND DATA S/ LIQUID METALS FOR	HEAT PIPES,	PROPERTIES, PLOTS	68041	D.3-01
30500	TION OF OPERATION OF ROTATING	HEAT PIPES=	DEMONSTRA	70089	E-09
21800	CAL AND EXPERIMENTAL STUDY OF	HEAT PIPES=	AN ANALYTI	68032	D.1-02
27200	TWO-COMPONENT	HEAT PIPES=		69062	C.1-03
28400	SOME OPERATING LIMITS ON	HEAT PIPES=		68025	C.1-03
07400	THEORY OF	HEAT PIPES=		65001	A-01
06100	INDEPENDENT	HEAT PIPES=		70036	B.4-03
06301	MATICAL MODELING OF CRYOGENIC	HEAT PIPES=	MATHE	71019	C.1-06
06400	RETICAL ANALYSIS OF CRYOGENIC	HEAT PIPES=	THEO	70071	D.1-07
05801	EFFECT OF MAGNETIC FIELDS ON	HEAT PIPES=		70045	C.1-05
05700	STATUS REPORT ON	HEAT PIPES=		64003	D.1-01

05300	HIGH TEMPERATURE LITHIUM	HEAT PIPES=		69092	D.3-01
05200	PERFORMANCE STUDIES ON	HEAT PIPES=		66027	D.1-01
07300	OF THE ENGINEERING THEORY OF	HEAT PIPES=	STATUS	67034	C.1-02
01800	EXPERIMENTAL	HEAT PIPES=		71045	E-11
19501	OR COMPRESSIBILITY EFFECTS IN	HEAT PIPES=	VAP	70062	C.4-04
11900		HEAT PIPES=		69082	D.1-05
13702	NSTEADY OPERATING BEHAVIOR OF	HEAT PIPES=	U	70090	E-09
09701	DEVELOPMENT OF CRYOGENIC	HEAT PIPES=		71025	D.1-07
21400	ATIONS OF ENERGY TRANSPORT IN	HEAT PIPES=	LIMIT	70049	C.1-06
16100	LIQUID-VAPOR INTERACTION IN	HEAT PIPES=		69078	C.4-04
16300	ATION AND TEST OF AN ALUMINUM	HEAT PIPES=	FABRIC	67032	B.3-03
10200	ANALYSIS AND DESIGN OF	HEAT PIPES=		70068	D.1-06
20500	ON THE OPERATION OF	HEAT PIPES=		65002	A-01
02501	NTROLLED VARIABLE CONDUCTANCE	HEAT PIPES=	FEEDBACK CO	71027	D.1-08
05000	OP IN THE VAPOR PHASE OF LONG	HEAT PIPES=	PRESSURE DR	67042	C.4-02
08501	TIONS AND STARTUP PROBLEMS OF	HEAT PIPES=	SONIC LIMITA	71032	E-10
23400	F GRAVITY ON HEAT TRANSFER IN	HEAT PIPES=	THE EFFECT O	70063	C.4-04
04500	SONIC HEAT TRANSFER LIMIT OF	HEAT PIPES=	THEORY OF THE	70053	C.2-03
25300	EXPERIMENTAL STUDY OF SODIUM	HEAT PIPES=	ANALYTICAL AND	69064	C.1-04
01600	NTERACTION AND EVAPORATION IN	HEAT PIPES=	LIQUID-VAPOR I	69072	C.4-02
15900	CELL SPACE RADIATOR UTILIZING	HEAT PIPES=	AN ATS-E SOLAR	69037	B.3-05
08900	VESTIGATIONS ON SODIUM FILLED	HEAT PIPES=	EXPERIMENTAL IN	67055	D.2-02
13701	ANSPORT OF OPTIMALLY DESIGNED	HEAT PIPES=	MAXIMUM HEAT TR	70055	C.2-03
06900	ERISTICS OF CAPILLARY-LIMITED	HEAT PIPES=	OPERATING CHARACT	67038	C.1-02
24300	DERATIONS ON HEAT TRANSFER IN	HEAT PIPES=	THEORETICAL CONSI	67039	C.2-01
25900	GY BY APPLICATION OF MODIFIED	HEAT PIPES=	/ CONTROL TECHNOLO	69038	B.3-06
24600	T POWER TRANSPORTED BY SODIUM	HEAT PIPES=	/ THE LIMITING HEA	69079	D.1-04
26500	URBINE REGENERATORS EMPLOYING	HEAT PIPES=	/ALUATION OF GAS T	68004	B.1-02
13700	SSESSMENT OF HEAT CARRIERS IN	HEAT PIPES=	/AMETERS FOR THE A	70047	C.1-05
00010	ECTRO-OSMOTIC FLOW PUMPING IN	HEAT PIPES=	/APPLICATION OF EL	71021	C.4-05
02201	CAPABILITIES OF ORGANIC FLUID	HEAT PIPES=	/CS AND LONG LIFE	71036	E-10
19510	ONIC VELOCITY LIMIT IN SODIUM	HEAT PIPES=	/FRICTION ON THE S	71022	C.4-05
15800	OWER SYSTEM CONCEPT EMPLOYING	HEAT PIPES=	/HERMIONIC SPACE P	68010	B.2-07
20501	ION OF ROTATING NON-CAPILLARY	HEAT PIPES=	/MENTAL INVESTIGAT	70043	C.1-05
29000	AN IRRADIATION CAPSULE USING	HEAT PIPES=	/N TEMPERATURES IN	70034	B.4-03
28100	ACUUM WALL FREE BLANKET USING	HEAT PIPES=	/NKET DESIGN - A V	70033	B.4-03
20400	HOT RESERVOIR GAS-CONTROLLED	HEAT PIPES=	/NT PERFORMANCE OF	70087	E-08
15000	ERATURE IN REACTORS COOLED BY	HEAT PIPES=	/ON POWER AND TEMP	69050	B.4-02
01200	CONCEPT USING ROD CONTROL AND	HEAT PIPES=	/ONIC SPACE POWER	69014	B.2-08
15901	NCONDENSIBLE GAS CONTROLLABLE	HEAT PIPES=	/PERFORMANCE OF NO	71026	D.1-07
24500	EDIA CAPABLE OF BEING USED IN	HEAT PIPES=	/RE IN CAPILLARY M	69077	C.4-04
20600	OPERATION OF LOW TEMPERATURE	HEAT PIPES=	/TE BOILING ON THE	69069	C.3-01
27000	STUDIES ON THE PERFORMANCE OF	HEAT PIPES=	/TEM FOR DETAILED	69093	E-05
21401	IMAL HEATING SURFACE LOADS IN	HEAT PIPES=	/Y GEOMETRY ON OPT	70044	C.1-05
24600	DETERMINATION OF THE LIMITING	HEAT POWER	TRANSPORTED BY SODI	69079	D.1-04
30200	OF HEAT PIPES TO THE SNAP-19	HEAT REJECTION	SYSTEM= /CATION	66016	B.3-01
14100	HERMIONIC P/ THE USE OF A NEW	HEAT REMOVAL	SYSTEM IN SPACE T	67024	B.2-06
13300	ENT UNIT THERMAL CONDITIONING	HEAT SINK	CONCEPTS= /N INSTRUM	67051	D.2-02
13400	ENT UNIT THERMAL CONDITIONING	HEAT SINK	CONCEPTS= /N INSTRUM	67054	D.2-02
28501	NALYSIS OF THE HEAT PIPE AS A	HEAT SINK	FOR SOLID-STATE RADI	70040	B.5-02
20700	SIS OF ADVANCED FAST-SPECTRUM	HEAT SOURCES	FOR SPACE APPLICA	69045	B.3-07
07100	FLUX FOR A SURFACE / BOILING	HEAT TRANSFER	AND MAXIMUM HEAT	63001	C.2-01
31100	IQUE AND VERSATILE DEVICE FOR	HEAT TRANSFER	APPLICATIONS= /N	67004	A-02
09910	UREMENTS OF FILM CONDENSATION	HEAT TRANSFER	COEFFICIENTS IN	71031	E-10

12500	ER= SMALL	OUT-OF-PILE THERMIONIC CONVERT	68009	B.2-07
27600	L VAPOR DEVICE FOR/ HEAT PIPE	OVEN - A NEW WELL-DEFINED META	69099	B.1-04
09700	ATIONS WIT/ A MILLIMETER WAVE	PARABOLIC ANTENNA FOR COMMUNIC	70027	B.3-09
13700	OF HEAT CARRIERS IN HEAT PIP/	PARAMETERS FOR THE ASSESSMENT	70047	C.1-05
00900	ZATION= EFFECTS OF CONDENSER	PARAMETERS ON HEAT PIPE OPTIMI	67040	C.3-01
09903	SEA RADIOISOTOPIC THERMOEL/ A	PARAMETRIC ANALYSIS OF A DEEP	70012	B.2-12
16001	MINARY PROGRAM PLAN HEAT PIPE	PARAMETRIC DATA= PRELI	70081	E-07
26101	SPACE S/ TECHNOLOGY STUDY OF	PASSIVE CONTROL OF HUMIDITY IN	66014	B.3-01
28600	TY CONTROL SYSTEMS / STUDY OF	PASSIVE TEMPERATURE AND HUMIDI	69091	D.3-01
26100	TY CONTROL SYSTEMS / STUDY OF	PASSIVE TEMPERATURE AND HUMIDI	68016	B.3-03
03400	HE SURFACE TENSION OF AG, TL,	PB, AND BI AT HIGH TEMPERATURE	68007	B.1-03
17400	HIGH	PERFORMANCE HEAT PIPE=	68040	D.2-03
08600	MENT= HEAT PIPE	PERFORMANCE IN A SPACE ENVIRON	68045	E-03
08700	Y FIELD= HEAT PIPE	PERFORMANCE IN A ZERO-G GRAVIT	68050	E-04
09920	RAVITY FIELD= HEAT PIPE	PERFORMANCE IN AN ARTIFICIAL G	71035	E-10
15400	OS-2 HEAT PIPE SYSTEM AND ITS	PERFORMANCE IN TEST AND IN ORB	70080	E-07
32900	OS-2 HEAT PIPE SYSTEM AND ITS	PERFORMANCE IN TEST AND IN ORB	68018	B.3-03
24900	HEAT PIPE=	PERFORMANCE MAP OF AN AMMONIA	70088	E-09
25100	EAT PIPE AND THE PHENOMENON /	PERFORMANCE MAP OF THE WATER H	69097	E-06
20900	IPE= THE	PERFORMANCE OF A SODIUM HEAT P	70082	E-07
06000	HEAT PIPE=	PERFORMANCE OF A WICK-LIMITED	69089	D.2-04
19600	THERMIONIC / INVESTIGATION OF	PERFORMANCE OF AN OUT-OF-CORE	69012	B.2-08
17910	PES AT MODERATE/ EXPERIMENTAL	PERFORMANCE OF GROOVED HEAT PI	71037	E-11
27000	M FOR DETAILED STUDIES ON THE	PERFORMANCE OF HEAT PIPES= /TE	69093	E-05
20400	A/ STEADY-STATE AND TRANSIENT	PERFORMANCE OF HOT RESERVOIR G	70087	E-08
15901	GAS CONTROLLABLE / DESIGN AND	PERFORMANCE OF NONCONDENSIBLE	71026	D.1-07
15500	PIPE SYSTEM=	PERFORMANCE OF THE GEOS-2 HEAT	69040	B.3-06
16101	RIMENTAL INVESTIGATION OF THE	PERFORMANCE OF VARIOUS WICK CO	71030	E-09
05200	PES=	PERFORMANCE STUDIES ON HEAT PI	66027	D.1-01
09800	TION OF THEORETICAL HEAT PIPE	PERFORMANCE= EVALUA	67037	C.1-02
08200	ECT OF VIBRATION ON HEAT PIPE	PERFORMANCE= THE EFF	68043	E-02
17600	ULTIMATE HEAT PIPE	PERFORMANCE=	69073	C.4-03
21601	OF LIMITING PLANAR HEAT PIPE	PERFORMANCE= /DIOGRAPHIC STUDY	70084	E-08
28401	UDINAL VIBRATION ON HEAT PIPE	PERFORMANCE= /EFFECT OF LONGIT	70083	E-07
21600	IMITATION ON PLANAR HEAT PIPE	PERFORMANCE= /FORMATION AS A L	69098	E-06
00700	ON THE	PERFORMENCE OF A HEAT PIPE=	66022	C.2-01
05000	PRESSURE DROP IN THE VAPOR	PHASE OF LONG HEAT PIPES=	67042	C.4-02
09902	PIPE WITH VERTICAL/ FLOODING	PHENOMENON IN A CRYOGENIC HEAT	70064	C.4-05
25100	F THE WATER HEAT PIPE AND THE	PHENOMENON OF NONCONDENSIBLE G	69097	E-06
09900	TWO	PIECE HEAT PIPE CONVERTER=	68006	B.1-03
		'PIPE ' NOT INDEXED		
13101	TON CYCLE VAPOR CHAMBER (HEAT	PIPE) RADIATOR STUDY= BRAY	71011	B.3-10
		'PIPES ' NOT INDEXED		
16001	= PRELIMINARY PROGRAM	PLAN HEAT PIPE PARAMETRIC DATA	70081	E-07
21600	FORMATION AS A LIMITATION ON	PLANAR HEAT PIPE PERFORMANCE= /	69098	E-06
21601	ADIOGRAPHIC STUDY OF LIMITING	PLANAR HEAT PIPE PERFORMANCE= /	70084	E-08
28500	IC TECHNOLOGY FOR OTHER POWER	PLANTS AS WELL= / PROVIDES BAS	70007	B.1-04
28300	PIPE RADIATOR FOR SPACE POWER	PLANTS= HEAT	69044	B.3-07
28200	OWER FOR A 50-MWT SPACE POWER	PLANTS= / RADIATOR FOR SPACE P	67031	B.3-02
24400	S FOR HEAT PIPES, PROPERTIES,	PLOTS AND DATA SHEETS= / METAL	68041	D.3-01
07000	ITS IN THE ATTAINMENT OF HIGH	POOL BOILING BURNOUT HEAT FLUX	64002	C.2-01
17900	EATING SURFACE BY A CAPILLARY	POROUS BODY AT LOW PRESSURES= /	70057	C.3-02
26900	G WATER HEAT TRANSFER THROUGH	POROUS MEDIA= /CTION IN BOILIN	70050	C.2-02
12600	T TRANSFER FROM THE WALL OF A	POROUS SOLID INVOLVING GAS INJ	70052	C.2-03

		'REPORT ' NOT INDEXED		
32300	SPACE ELECTRIC POWER	RESEARCH AND DEVELOPMENT=	69068	C.3-01
32400	SPACE ELECTRIC POWER	RESEARCH AND DEVELOPMENT=	69076	C.4-03
32000	LAMOS S/ SPACE ELECTRIC POWER	RESEARCH AND DEVELOPMENT LOS A	68034	D.1-03
32200	SPACE ELECTRIC POWER	RESEARCH AND DEVELOPMENT=	68051	E-04
32100	SPACE ELECTRIC POWER	RESEARCH AND DEVELOPMENT=	68052	E-04
04700	HEAT PIPE	RESEARCH IN EUROPE=	69060	C.1-03
04800	EAT PIPE THERMIONIC CONVERTER	RESEARCH IN EUROPE= H	69025	B.2-11
22300	LOW-TEMPERATURE HEAT PIPE	RESEARCH PROGRAM=	69094	E-05
13300	NIT THERMAL CONDITIONING HEA/	RESEARCH STUDY ON INSTRUMENT U	67051	D.2-02
13400	NIT THERMAL CONDITIONING HEA/	RESEARCH STUDY ON INSTRUMENT U	67054	D.2-02
22500	LOW TEMPERATURE HEAT PIPE	RESEARCH=	68054	E-05
20400	TRANSIENT PERFORMANCE OF HOT	RESERVOIR GAS-CONTROLLED HEAT	70037	E-08
03500	E THE/ INTEGRATED CS-GRAPHITE	RESERVOIR SYSTEM IN A HEAT PIP	67023	B.2-06
04000	TH GRAPHITE ABSORPTION CESIUM	RESERVOIR WORKING AT COLLECTOR	68014	B.2-08
12701	2 - DEVELOPMENT OF ADSORPTION	RESERVOIR= /PICAL REPORT TASK	70017	B.2-13
01500	ES AT HIGH TEMPE/ PRELIMINARY	RESULTS OF A STUDY OF HEAT PIP	69061	C.1-03
09500	ERMIONIC ENERGY CONVERTERS=	REVIEW OF FOSSIL-FUEL-FIRED TH	67015	B.2-04
06300	APPLICATIONS= A CRITICAL	REVIEW OF HEAT PIPE THEORY AND	68002	A-02
26800	ON OF HEAT PIPE TECHNOLOGY TO	ROCKET ENGINE COOLING= /LICATI	69035	B.3-05
23820	PIPE TECHNOLOGY FOR ADVANCED	ROCKET THRUST CHAMBERS= HEAT	70025	B.3-08
01200	NIC SPACE POWER CONCEPT USING	ROD CONTROL AND HEAT PIPES= /0	69014	B.2-08
07000	SURFACE DEPOSITS IN THE/ THE	ROLES OF CAPILLARY WICKING AND	64002	C.2-01
13500	S HOLLOW SHAFT FOR TRANS/ THE	ROTATING HEAT PIPE - A WICKLES	69081	D.1-04
30500	DEMONSTRATION OF OPERATION OF	ROTATING HEAT PIPES=	70089	E-09
20501	EXPERIMENTAL INVESTIGATION OF	ROTATING NON-CAPILLARY HEAT PI	70043	C.1-05
07901	TAL DESIGN AND OPERATION OF A	ROTATING WICKLESS HEAT PIPE= /	70085	E-08
31600	NT ATOMIC ENERGY COMMISSION -	SANDIA LAB HEAT PIPE CONFERENC	67063	C.1-02
08500		SATELLITE HEAT PIPE=	65012	B.3-01
29001	HEAT PIPES IN	SATELLITE TECHNOLOGY=	71010	B.3-10
24100	PIPES AND VAPOR CHAMBERS FOR	SATELLITE THERMAL BALANCE= /AT	70021	B.3-08
00800	ICATION TO A GRAVITY-GRADIENT	SATELLITE= HEAT PIPE APPL	69046	B.3-07
28800	PIPE EXPERIMENT FOR THE SE-4	SATELLITE= / CONTROLLABLE HEAT	65016	E-01
09700	UNICATIONS WITH A SYNCHRONOUS	SATELLITE= /C ANTENNA FOR COMM	70027	B.3-09
15910	THERMAL	SCALE MODELING OF A HEAT PIPE=	71018	C.1-06
16000	THERMAL	SCALE MODELING OF A HEAT PIPE=	70046	C.1-05
		'SCIENTIFIC' NOT INDEXED		
01700	INVESTIGATION OF FLOW THROUGH	SCREENS=	50001	C.4-01
09903	PARAMETRIC ANALYSIS OF A DEEP	SEA RADIOISOTOPIC THERMOELECTR	70012	B.2-12
29100		SECONDARY POWER=	69039	B.3-06
15000	ERATURE IN REACTO/ REACTIVITY	SELF-CONTROL ON POWER AND TEMP	69050	B.4-02
13500	HEAT PIPE - A WICKLESS HOLLOW	SHAFT FOR TRANSFERRING HIGH HE	69081	D.1-04
24400	S, PROPERTIES, PLOTS AND DATA	SHEETS= / METALS FOR HEAT PIPE	68041	D.3-01
26900	N IN BOILING WATER HEAT TR/ A	SHORT STUDY OF CAPILLARY ACTIO	70050	C.2-02
08300	ING THE BOILING OF LITHIUM OR	SILVER= /CTANCE DEVICES UTILIZ	65015	E-01
21001	ION OF CONSTRAINTS IN THERMAL	SIMILITUDE= INVESTIGAT	70042	C.1-04
21000	ION OF CONSTRAINTS IN THERMAL	SIMILITUDE= INVESTIGAT	70041	C.1-04
17800	A REACTOR SU/ EXPERIMENTS FOR	SIMULATING HEAT TRANSFER FROM	68023	B.4-02
16101	ARIOUS WICK CONFIGURATIONS IN	SINGLE AND TWO FLUID HEAT PIPE	71030	E-09
13400	NIT THERMAL CONDITIONING HEAT	SINK CONCEPTS= /N INSTRUMENT U	67054	D.2-02
13300	NIT THERMAL CONDITIONING HEAT	SINK CONCEPTS= /N INSTRUMENT U	67051	D.2-02
28501	IS OF THE HEAT PIPE AS A HEAT	SINK FOR SOLID-STATE RADIOFREQ	70040	B.5-02
26600	Y OF DRY AND LIQUID-SATURATED	SINTERED FIBER METAL WICKS= /T	70054	C.2-03
12500	ONVERTER=	SMALL OUT-OF-PILE THERMIONIC C	68009	B.2-07

30200	LICATION OF HEAT PIPES TO THE	SNAP-19 HEAT REJECTION SYSTEM=	66016	B.3-01
02500	APPLICATION OF HEAT PIPES TO	SNAP-29=	68011	B.2-07
16110	RANSFER IN A HEAT PIPE WITH A	SODIUM COOLANT= /AT AND MASS T	71033	E-10
08900	XPERIMENTAL INVESTIGATIONS ON	SODIUM FILLED HEAT PIPES= E	67055	D.2-02
03800	TRANSFER MEASUREMENTS USING A	SODIUM HEAT PIPE WORKING AT LO	68027	C.2-01
20900	THE PERFORMANCE OF A	SODIUM HEAT PIPE=	70082	E-07
09200	OF VAPOR VELOCITY LIMIT IN A	SODIUM HEAT PIPE= /ENTAL STUDY	69075	C.4-03
25300	CAL AND EXPERIMENTAL STUDY OF	SODIUM HEAT PIPES= ANALYTI	69064	C.1-04
24600	ING HEAT POWER TRANSPORTED BY	SODIUM HEAT PIPES= / THE LIMIT	69079	D.1-04
19510	N THE SONIC VELOCITY LIMIT IN	SODIUM HEAT PIPES= /FRICTION O	71022	C.4-05
15900	IZING HEAT PIPES= AN ATS-E	SOLAR CELL SPACE RADIATOR UTIL	69037	B.3-05
31900	ELOPMENT=	SOLAR THERMIONIC GENERATOR DEV	69083	D.1-05
12600	FER FROM THE WALL OF A POROUS	SOLID INVOLVING GAS INJECTION	70052	C.2-03
28501	HEAT PIPE AS A HEAT SINK FOR	SOLID-STATE RADIOFREQUENCY SOU	70040	B.5-02
		*SOME * NOT INDEXED		
04500	EAT PIPES= THEORY OF THE	SONIC HEAT TRANSFER LIMIT OF H	70053	C.2-03
08501	PROBLEMS OF HEAT PIPES=	SONIC LIMITATIONS AND STARTUP	71032	E-10
19510	/ EFFECTS OF FRICTION ON THE	SONIC VELOCITY LIMIT IN SODIUM	71022	C.4-05
20700	F ADVANCED FAST-SPECTRUM HEAT	SOURCES FOR SPACE APPLICATION=	69045	B.3-07
28501	OR SOLID-STATE RADIOFREQUENCY	SOURCES= /IPE AS A HEAT SINK F	70040	B.5-02
20700	AST-SPECTRUM HEAT SOURCES FOR	SPACE APPLICATION= /ADVANCED F	69045	B.3-07
07900	LOP THE THEORETICAL DESIGN OF	SPACE BORN ELECTROSTATICALLY F	69030	B.3-04
32602	ROGRAM=	SPACE ELECTRIC POWER R AND D P	70016	B.2-13
32400	AND DEVELOPMENT=	SPACE ELECTRIC POWER RESEARCH	69076	C.4-03
32501	ROGRAM=	SPACE ELECTRIC POWER R AND D P	70066	D.1-06
32300	AND DEVELOPMENT=	SPACE ELECTRIC POWER RESEARCH	69068	C.3-01
32100	AND DEVELOPMENT=	SPACE ELECTRIC POWER RESEARCH	68052	E-04
32200	AND DEVELOPMENT=	SPACE ELECTRIC POWER RESEARCH	68051	E-04
32000	AND DEVELOPMENT LOS ALAMOS S/	SPACE ELECTRIC POWER RESEARCH	68034	D.1-03
08600	HEAT PIPE PERFORMANCE IN A	SPACE ENVIRONMENT=	68045	E-03
24200	N=	SPACE EXPERIMENT THERMAL DESIG	70023	B.3-08
30100	ADVANCED	SPACE NUCLEAR POWER PROGRAM=	68022	B.4-01
21910	IT-CORE HEAT PIPE REACTOR FOR	SPACE POWER APPLICATIONS= /SPL	71014	B.4-04
01200	CONTROL/ A NUCLEAR THERMIONIC	SPACE POWER CONCEPT USING ROD	69014	B.2-08
01300	THERMIONIC HEAT PIPE	SPACE POWER CONCEPT=	68012	B.2-07
15700	IC DID/ A REACTOR CONCEPT FOR	SPACE POWER EMPLOYING THERMION	68013	B.2-07
28200	POWE/ HEAT PIPE RADIATOR FOR	SPACE POWER FOR A 50-MWT SPACE	67031	B.3-02
28300	HEAT PIPE RADIATOR FOR	SPACE POWER PLANTS=	69044	B.3-07
28200	FOR SPACE POWER FOR A 50-MWT	SPACE POWER PLANTS= / RADIATOR	67031	B.3-02
04900	IPE THERMIONIC CONVERTERS FOR	SPACE POWER SUPPLIES= / HEAT P	66003	B.2-02
23700	HEAT-PIPE COOLED FAST REACTOR	SPACE POWER SUPPLY= A	69033	B.3-04
15800	LOYING HE/ NUCLEAR THERMIONIC	SPACE POWER SYSTEM CONCEPT EMP	68010	B.2-07
19600	OF AN OUT-OF-CORE THERMIONIC	SPACE POWER SYSTEM= /RFORMANCE	69012	B.2-08
22601	MWT (375KWE) NUCLEAR-ELECTRIC	SPACE POWER SYSTEM= /N OF A 2-	71015	B.4-04
19700	OF AN OUT-OF-CORE THERMIONIC	SPACE POWER SYSTEM= ANALYSIS	69017	B.2-09
00600	OISOTOPE HEAT-PIPE-THERMIONIC	SPACE POWER SYSTEM= /OF A RADI	71042	B.3-11
19800	OUT-OF-CORE THERMIONIC	SPACE POWER=	69021	B.2-10
22600	WE NUCLEAR RANKINE SYSTEM FOR	SPACE POWER= /DESIGN OF A 10-M	70029	B.3-09
22200	DEVELOPMENT OF AN ADVANCED	SPACE RADIATION SYSTEM=	69041	B.3-06
15900	PIPES= AN ATS-E SOLAR CELL	SPACE RADIATOR UTILIZING HEAT	69037	B.3-05
27400	IGN OF A 50000 WATT HEAT PIPE	SPACE RADIATOR= DES	69048	B.3-07
14700	AMBER/ FEASIBILITY STUDIES OF	SPACE RADIATORS USING VAPOR CH	71040	B.3-11
05100	IPE THERMIONIC CONVERTERS FOR	SPACE REACTORS= /PES OF HEAT P	65011	B.2-02
09600	R= HEAT PIPE -	SPACE SPINOFF FOR HEAT TRANSFE	70005	A-04

05200	PERFORMANCE	STUDIES ON HEAT PIPES=	66027	D.1-01
27000	VERSATILE SYSTEM FOR DETAILED	STUDIES ON THE PERFORMANCE OF	69093	E-05
18300	VAPOR-CHAMBER FIN	STUDIES=	66028	D.2-01
18600	VAPOR CHAMBER FIN	STUDIES=	66029	D.2-01
18700	VAPOR-CHAMBER FIN	STUDIES=	66030	D.2-01
01901	D AND MULTI-COMPONENT HI/ THE	STUDY AND CLASSIFICATION OF TW	71001	A-04
24000	PROPULSION SYSTEM= A	STUDY OF A NUCLEAR THERMIONIC	67013	B.2-04
04001	NUCLEAR THERMIONIC/ A DESIGN	STUDY OF A 350 KWE OUT-OF-CORE	70011	B.2-12
26900	OILING WATER HEAT TR/ A SHORT	STUDY OF CAPILLARY ACTION IN B	70050	C.2-02
23200	RMAL IRRADIATION ASSEMBLY FOR	STUDY OF FAST NEUTRON DAMAGE T	68021	B.4-01
26300	S IN NUCLEAR AIRCRAFT PROP/ A	STUDY OF HEAT PIPE APPLICATION	70020	B.3-07
01500	MPE/ PRELIMINARY RESULTS OF A	STUDY OF HEAT PIPES AT HIGH TE	69061	C.1-03
21800	N ANALYTICAL AND EXPERIMENTAL	STUDY OF HEAT PIPES= A	68032	D.1-02
21601	PIPE PE/ NEUTRON RADIOGRAPHIC	STUDY OF LIMITING PLANAR HEAT	70084	E-08
06401	S IN A HEAT PIPE= A	STUDY OF NONCONDENSIBLE EFFECT	71020	C.4-05
26101	MIDITY IN SPACE S/ TECHNOLOGY	STUDY OF PASSIVE CONTROL OF HU	66014	B.3-01
28600	ND HUMIDITY CONTROL SYSTEMS /	STUDY OF PASSIVE TEMPERATURE A	69091	D.3-01
26100	ND HUMIDITY CONTROL SYSTEMS /	STUDY OF PASSIVE TEMPERATURE A	68016	B.3-03
25300	ANALYTICAL AND EXPERIMENTAL	STUDY OF SODIUM HEAT PIPES=	69064	C.1-04
11100	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	70051	C.2-02
10900	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	69065	C.1-04
11800	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	68049	E-03
11500	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	67036	C.1-02
11600	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	68048	E-03
11400	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	67041	C.4-02
11300	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	67059	E-02
11700	ERISTICS OF THE HEAT PIPE=	STUDY OF THE OPERATING CHARACT	68029	C.3-01
09200	IN A SODIUM HEA/ EXPERIMENTAL	STUDY OF VAPOR VELOCITY LIMIT	69075	C.4-03
20800	N EXPERIMENTAL AND ANALYTICAL	STUDY OF WATER HEAT PIPES FOR	69095	E-06
26700	Y-P/ EXPERIMENTAL FEASIBILITY	STUDY OF WATER-FILLED CAPILLAR	66024	C.4-01
15801	TERISTICS IN A LONGITUDINA/ A	STUDY OF WIRE MESH WICK CHARAC	70074	D.2-05
13400	AL CONDITIONING HEA/ RESEARCH	STUDY ON INSTRUMENT UNIT THERM	67054	D.2-02
13300	AL CONDITIONING HEA/ RESEARCH	STUDY ON INSTRUMENT UNIT THERM	67051	D.2-02
07900	HEORETICAL DESIGN/ ANALYTICAL	STUDY PROGRAM TO DEVELOP THE T	69030	B.3-04
04010	ITY OF A FEEDBACK CONTROLLED/	STUDY TO EVALUATE THE FEASIBIL	71024	D.1-07
13101	CHAMBER (HEAT PIPE) RADIATOR	STUDY= BRAYTON CYCLE VAPOR	71011	B.3-10
07600	E SYSTEM - ICICLE FEASIBILITY	STUDY= / ISOTOPE COOLING ENGIN	70009	B.1-05
26000	HEAT PIPE DEVICES FOR SPACE	SUIT TEMPERATURE CONTROL=	69032	B.3-04
25800	HEAT PIPES FOR SPACE	SUIT TEMPERATURE CONTROL=	69047	B.3-07
25900	OLOGY / ADVANCEMENTS OF SPACE	SUIT TEMPERATURE CONTROL TECHN	69038	B.3-06
26101	CONTROL OF HUMIDITY IN SPACE	SUITS= /OLOGY STUDY OF PASSIVE	66014	B.3-01
28600	OL SYSTEMS FOR ADVANCED SPACE	SUITS= /URE AND HUMIDITY CONTR	69091	D.3-01
26100	OL SYSTEMS FOR ADVANCED SPACE	SUITS= /URE AND HUMIDITY CONTR	68016	B.3-03
07100	UX FOR A SURFACE WITH COOLANT	SUPPLIED BY CAPILLARY WICKING=	63001	C.2-01
21900	APPLICATION FOR NUCLEAR POWER	SUPPLIES IN SPACE= /AND THEIR	66011	B.2-04
04900	IC CONVERTERS FOR SPACE POWER	SUPPLIES= / HEAT PIPE THERMION	66003	B.2-02
14100	TEM IN SPACE THERMIONIC POWER	SUPPLIES= /EW HEAT REMOVAL SYS	67024	B.2-06
23600	OF A 1 KWE FAST REACTOR POWER	SUPPLY= DESIGN	67033	B.4-01
23700	OLED FAST REACTOR SPACE POWER	SUPPLY= A HEAT-PIPE CO	69033	B.3-04
17900	ATER DELIVERED TO THE HEATING	SURFACE BY A CAPILLARY POROUS	70057	C.3-02
07000	OLES OF CAPILLARY WICKING AND	SURFACE DEPOSITS IN THE ATTAIN	64002	C.2-01
21401	Y GEOMETRY ON OPTIMAL HEATING	SURFACE LOADS IN HEAT PIPES= /	70044	C.1-05
03300	THE LIQUID EARTH ALKALINE M/	SURFACE TENSION AND DENSITY OF	67009	B.1-02
03400	AND BI AT HIGH TEMPERAT/ THE	SURFACE TENSION OF AG, TL, PB,	68007	B.1-03

02900	METALS= THE	SURFACE TENSION OF THE ALKALI	67012	B.1-02
17800	HEAT TRANSFER FROM A REACTOR	SURFACE TO CESIUM VAPOR CONVER	68023	B.4-02
04100	ARY GROOVES=	SURFACE WETTING THROUGH CAPILL	70059	C.3-02
07100	R AND MAXIMUM HEAT FLUX FOR A	SURFACE WITH COOLANT SUPPLIED	63001	C.2-01
13501	ATE BOILING FROM MESH COVERED	SURFACES= /ESTIGATION OF NUCLE	70058	C.3-02
11000	FER FROM FLOODED WICK COVERED	SURFACES= /RIZATION HEAT TRANS	69070	C.3-02
05901	OR AIRCRAFT ELECTRONIC EQU/ A	SURVEY OF COOLING TECHNIQUES F	70039	B.5-02
23100	OM HEAT PIPE INVESTIGATIONS=	SURVEY OF LOS ALAMOS AND EURAT	66001	A-01
02200	TO CONTROL TWT TEMPERATURE IN	SYNCHRONOUS ORBIT= /EAT PIPES	70030	B.3-09
09700	NNA FOR COMMUNICATIONS WITH A	SYNCHRONOUS SATELLITE= /C ANTE	70027	B.3-09
07600	OGENIC ISOTOPE COOLING ENGINE	SYSTEM - ICICLE FEASIBILITY ST	70009	B.1-05
31800	NG= REACTOR,	SYSTEM AND COMPONENT ENGINEERI	70077	D.3-02
32900	TEST AN/ THE GEOS-2 HEAT PIPE	SYSTEM AND ITS PERFORMANCE IN	68018	B.3-03
15400	TEST AN/ THE GEOS-2 HEAT PIPE	SYSTEM AND ITS PERFORMANCE IN	70080	E-07
15800	UCLEAR THERMIONIC SPACE POWER	SYSTEM CONCEPT EMPLOYING HEAT	68010	B.2-07
27000	/ DEVELOPMENT OF A VERSATILE	SYSTEM FOR DETAILED STUDIES ON	69093	E-05
03700	COOLING	SYSTEM FOR NUCLEAR REACTORS=	68020	B.4-01
22600	N OF A 10-MWE NUCLEAR RANKINE	SYSTEM FOR SPACE POWER= /DESIG	70029	B.3-09
25110	CONTROL= HEAT PIPE	SYSTEM FOR SPACECRAFT THERMAL	71012	B.3-10
03500	EGRATED CS-GRAPHITE RESERVOIR	SYSTEM IN A HEAT PIPE THERMION	67023	B.2-06
14100	THE USE OF A NEW HEAT REMOVAL	SYSTEM IN SPACE THERMIONIC POW	67024	B.2-06
21200	PUMPING OMNITRON ULTRA-VACUUM	SYSTEM USING HEAT PIPES AND ME	69011	B.1-04
23000	ONS ON A VAPORIZATION COOLING	SYSTEM WITH CAPILLARY DISTRIBU	68028	C.3-01
15500	MANCE OF THE GEOS-2 HEAT PIPE	SYSTEM= PERFOR	69040	B.3-06
21901	AT PIPE - A NEW HEAT TRANSFER	SYSTEM= HE	71002	A-05
05401	T PIPE THERMIONIC DIODE POWER	SYSTEM= HEA	71008	B.2-14
24000	NUCLEAR THERMIONIC PROPULSION	SYSTEM= A STUDY OF A	67013	B.2-04
22200	F AN ADVANCED SPACE RADIATION	SYSTEM= DEVELOPMENT O	69041	B.3-06
19700	F-CORE THERMIONIC SPACE POWER	SYSTEM= ANALYSIS OF AN OUT-O	69017	B.2-09
04001	NUCLEAR THERMIONIC CONVERTER	SYSTEM= /A 350 KWE OUT-OF-CORE	70011	B.2-12
30200	TO THE SNAP-19 HEAT REJECTION	SYSTEM= /CATION OF HEAT PIPES	66016	B.3-01
07501	OGENIC ISOTOPE COOLING ENGINE	SYSTEM= /ICLE - INTEGRATED CRY	70010	B.1-05
22900	A NUCLEAR AIRCRAFT PROPULSION	SYSTEM= /ION OF HEAT PIPES TO	70024	B.3-08
25500	RMIONIC-CONVERTER - HEAT PIPE	SYSTEM= /MEASUREMENTS ON A THE	67060	E-02
22601	NUCLEAR-ELECTRIC SPACE POWER	SYSTEM= /N OF A 2-MWT (375KWE)	71015	B.4-04
00600	T-PIPE-THERMIONIC SPACE POWER	SYSTEM= /OF A RADIOISOTOPE HEA	71042	B.3-11
02400	OISOTOPIC THERMODYNAMIC POWER	SYSTEM= /R FLATTENING FOR RADI	69052	B.4-02
19600	F-CORE THERMIONIC SPACE POWER	SYSTEM= /RFORMANCE OF AN OUT-O	69012	B.2-08
16600	IES OF LIQUID METAL HEAT PIPE	SYSTEMS AT 1000 TO 1800C= /TUD	70075	D.3-02
28600	PERATURE AND HUMIDITY CONTROL	SYSTEMS FOR ADVANCED SPACE SUI	69091	D.3-01
26100	PERATURE AND HUMIDITY CONTROL	SYSTEMS FOR ADVANCED SPACE SUI	68016	B.3-03
06410	CIRCUMFERENTIAL HEAT PIPE	SYSTEMS FOR LARGE STRUCTURES=	71023	D.1-07
24700	A LOOK AT NUCLEAR THERMIONIC	SYSTEMS=	67016	B.2-05
10300	AT PIPES TO ENERGY CONVERSION	SYSTEMS= APPLICABILITY OF HE	70001	A-04
26300	N NUCLEAR AIRCRAFT PROPULSION	SYSTEMS= / PIPE APPLICATIONS I	70020	B.3-07
04600	ES WITH NIOBIUM-1ZIRCONIUM OR	TANTALUM AS WALL MATERIAL= /IP	70079	D.3-03
12701	C TECHNOLOGY - TOPICAL REPORT	TASK 2 - DEVELOPMENT OF ADSORP	70017	B.2-13
12101	REMENT OF THERMAL CONDUCTIVI/	TECHNIQUE FOR THE DIRECT MEASU	71003	B.1-05
05901	ONIC EQU/ A SURVEY OF COOLING	TECHNIQUES FOR AIRCRAFT ELECTR	70039	B.5-02
20000	ADVANCED HEAT PIPE THERMIONIC	TECHNOLOGY - DEVELOPMENT OF HI	69015	B.2-09
12701	ADVANCED HEAT PIPE THERMIONIC	TECHNOLOGY - TOPICAL REPORT TA	70017	B.2-13
25900	PACE SUIT TEMPERATURE CONTROL	TECHNOLOGY BY APPLICATION OF M	69038	B.3-06
20001	ADVANCED HEAT PIPE THERMIONIC	TECHNOLOGY DEVELOPMENT OF HIGH	70013	B.2-12
23820	THRUST CHAMBERS= HEAT PIPE	TECHNOLOGY FOR ADVANCED ROCKET	70025	B.3-08

28500	RANKINE CYCLE PROVIDES BASIC	TECHNOLOGY FOR OTHER POWER PLA	70007	B.1-04
29200	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	65014	D.1-01
29800	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	67058	E-02
29500	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	66019	C.1-01
30000	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	67062	E-02
29600	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	66020	C.1-01
29400	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	66018	C.1-01
29700	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	66021	C.1-02
29900	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	67061	E-02
29300	PORT - ART= ADVANCED REACTOR	TECHNOLOGY QUARTERLY STATUS RE	65013	C.1-01
26101	NTROL OF HUMIDITY IN SPACE S/	TECHNOLOGY STUDY OF PASSIVE CO	66014	B.3-01
26800	OLI/ APPLICATION OF HEAT PIPE	TECHNOLOGY TO ROCKET ENGINE CO	69035	B.3-05
29001	HEAT PIPES IN SATELLITE	TECHNOLOGY=	71010	B.3-10
14300	ADVANCES IN HEAT PIPE	TECHNOLOGY=	69028	B.2-12
31402	LTEP= LARGE	TELESCOPE EXPERIMENT PROGRAM -	70037	B.5-02
03000	PRESSURE MEASUREMENTS AT HIGH	TEMPERATURE AND HIGH PRESSURE=	65005	B.1-01
26100	OL SYSTEMS / STUDY OF PASSIVE	TEMPERATURE AND HUMIDITY CONTR	68016	B.3-03
28600	OL SYSTEMS / STUDY OF PASSIVE	TEMPERATURE AND HUMIDITY CONTR	69091	D.3-01
25900	/ ADVANCEMENTS OF SPACE SUIT	TEMPERATURE CONTROL TECHNOLOGY	69038	B.3-06
26000	T PIPE DEVICES FOR SPACE SUIT	TEMPERATURE CONTROL= HEA	69032	B.3-04
25800	HEAT PIPES FOR SPACE SUIT	TEMPERATURE CONTROL=	69047	B.3-07
02600	HEAT PIPES FOR	TEMPERATURE CONTROL=	69010	B.1-04
15200	AL EVALUATION OF AN AUTOMATIC	TEMPERATURE CONTROLLED HEAT PI	71043	B.1-05
20200	EAT PIPE WICKS= ANALYSIS OF	TEMPERATURE DISTRIBUTIONS IN H	69063	C.1-04
20600	ILING ON THE OPERATION OF LOW	TEMPERATURE HEAT PIPES= /TE BO	69069	C.3-01
22500	= LOW	TEMPERATURE HEAT PIPE RESEARCH	68054	E-05
27300	UE DEVICE FOR T/ THE CONSTANT	TEMPERATURE HEAT PIPE - A UNIQ	69036	B.3-05
15000	ITY SELF-CONTROL ON POWER AND	TEMPERATURE IN REACTORS COOLED	69050	B.4-02
02200	NAL HEAT PIPES TO CONTROL TWT	TEMPERATURE IN SYNCHRONOUS ORB	70030	B.3-09
13800	Y= HIGH	TEMPERATURE INORGANIC CHEMISTR	67007	B.1-01
04600	WITH NIOB/ CORROSION IN HIGH	TEMPERATURE LITHIUM HEAT PIPES	70079	D.3-03
05300	= HIGH	TEMPERATURE LITHIUM HEAT PIPES	69092	D.3-01
20800	WATER HEAT PIPES FOR MODERATE	TEMPERATURE RANGES= /STUDY OF	69095	E-06
31000	FERS HEAT WITH NEARLY UNIFORM	TEMPERATURE= HEAT PIPE TRANS	69006	A-03
03600	EAT PIPE OPERATING AT EMITTER	TEMPERATURE= / TRANSFER OF A H	66015	B.3-01
01500	A STUDY OF HEAT PIPES AT HIGH	TEMPERATURE= /NARY RESULTS OF	69061	C.1-03
04000	ESERVOIR WORKING AT COLLECTOR	TEMPERATURE= /ORPTION CESIUM R	68014	B.2-08
03400	OF AG, TL, PB, AND BI AT HIGH	TEMPERATURE= /SURFACE TENSION	68007	B.1-03
12101	THERMAL CONDUCTIVITY AT HIGH	TEMPERATURES BY THE USE OF A H	71003	B.1-05
29000	/ ACHIEVING UNIFORM SPECIMEN	TEMPERATURES IN AN IRRADIATION	70034	B.4-03
17910	ROOVED HEAT PIPES AT MODERATE	TEMPERATURES= /ERFORMANCE OF G	71037	E-11
03300	UID EARTH ALKALINE M/ SURFACE	TENSION AND DENSITY OF THE LIQ	67009	B.1-02
03400	AT HIGH TEMPERAT/ THE SURFACE	TENSION OF AG, TL, PB, AND BI	68007	B.1-03
02900	THE SURFACE	TENSION OF THE ALKALI METALS=	67012	B.1-02
15400	SYSTEM AND ITS PERFORMANCE IN	TEST AND IN ORBIT= /HEAT PIPE	70080	E-07
32900	SYSTEM AND ITS PERFORMANCE IN	TEST AND IN ORBIT= /HEAT PIPE	68018	B.3-03
30400	CASCADED THERMOELECTRIC	TEST GENERATOR=	69013	B.2-08
02700	CONSTRUCTION AND	TEST OF A FLEXIBLE HEAT PIPE=	70086	E-08
16300	= FABRICATION AND	TEST OF AN ALUMINUM HEAT PIPES	67032	B.3-03
16800	RCA	TEST THERMAL ENERGY PIPE=	66032	E-01
09710	THE DESIGN, FABRICATION, AND	TESTING OF A VARIABLE CONDUCTA	71028	D.1-08
02601	Y HEAT PIPE - DESIGN ANALYSIS	TESTING= /RONOMICAL OBSERVATOR	70059	D.1-06
05400	00 DEGREES C= HEAT PIPE LIFE	TESTS AT 1600 DEGREES C AND 10	68055	E-05
28000	DEVELOPMENT AND FEASIBILITY	TESTS OF ISOTHERMAL IRRADIATOR	70008	B.1-05

08300	H THERMAL CONDUCTANCE DEVICES	UTILIZING THE BOILING OF LITHI	65015	E-01
28100	PPROACH TO BLANKET DESIGN - A	VACUUM WALL FREE BLANKET USING	70033	B.4-03
21600	N RADIOGRAPHIC EXAMINATION OF	VAPOR BUBBLE FORMATION AS A LI	69098	E-06
13101	ATOR STUDY= BRAYTON CYCLE	VAPOR CHAMBER (HEAT PIPE) RADI	71011	B.3-10
18600		VAPOR CHAMBER FIN STUDIES=	66029	D.2-01
14700	DIES OF SPACE RADIATORS USING	VAPOR CHAMBER FINS= /ILITY STU	71040	B.3-11
17000	CATI/ NOTES ON HEAT PIPES AND	VAPOR CHAMBERS AND THEIR APPLI	67028	B.3-02
24100	HERMAL BALANC/ HEAT PIPES AND	VAPOR CHAMBERS FOR SATELLITE T	70021	B.3-08
21100	TROL OF SPACE/ HEAT PIPES AND	VAPOR CHAMBERS FOR THERMAL CON	68019	B.3-03
16900	TROL OF SPACE/ HEAT PIPES AND	VAPOR CHAMBERS FOR THERMAL CON	67045	D.1-02
19501	IN HEAT PIPES=	VAPOR COMPRESSIBILITY EFFECTS	70062	C.4-04
17800	M A REACTOR SURFACE TO CESIUM	VAPOR CONVERTERS= /RANSFER FRO	68023	B.4-02
27600	EN - A NEW WELL-DEFINED METAL	VAPOR DEVICE FOR SPECTROSCOPIC	69099	B.1-04
12200	A 25KW HOLLOW CATHODE LITHIUM	VAPOR MPD ARC JET= /NTS USING	69007	B.1-03
05000	= PRESSURE DROP IN THE	VAPOR PHASE OF LONG HEAT PIPES	67042	C.4-02
03200	TALS IN THE PRESSURE RANGE 0/	VAPOR PRESSURE OF DIFFERENT ME	67010	B.1-02
03100	THE PRESSURE RANGE OF 4/ THE	VAPOR PRESSURE OF YTTERBIUM IN	67011	B.1-02
03800	DIUM HEAT PIPE WORKING AT LOW	VAPOR PRESSURE= /TS USING A SO	68027	C.2-01
19500	F HEAT PIPES OPERATING AT LOW	VAPOR PRESSURE= /VESTIGATION O	69071	C.4-02
09200	UM HEA/ EXPERIMENTAL STUDY OF	VAPOR VELOCITY LIMIT IN A SODI	69075	C.4-03
14900	TEMPERATURE DIRECT-CONDENSING	VAPOR-CHAMBER FIN AND CONDUCTI	66017	C.1-01
18300		VAPOR-CHAMBER FIN STUDIES=	66028	D.2-01
18700		VAPOR-CHAMBER FIN STUDIES=	66030	D.2-01
18200	ERATING CHARACTERISTICS OF F/	VAPOR-CHAMBER FIN STUDIES - OP	68047	E-03
18100	ANSPORT PROPERTIES AND BOILI/	VAPOR-CHAMBER FIN STUDIES - TR	67053	D.2-02
14800	ANALYSIS AND EVALUATION OF A	VAPOR-CHAMBER FIN-TUBE RADIATO	65004	B.1-01
03000	HIGH TEMPERA/ NEW METHOD FOR	VAPOR-PRESSURE MEASUREMENTS AT	65005	B.1-01
23000	EORETICAL CONSIDERATIONS ON A	VAPORIZATION COOLING SYSTEM WI	68028	C.3-01
11000	M FLOODED WICK COVERED SURFA/	VAPORIZATION HEAT TRANSFER FRO	69070	C.3-02
11200	CAPILLARY WICK STRUCTURES=	VAPORIZATION HEAT TRANSFER IN	69067	C.2-02
00400	M FLOODED WICK=	VAPORIZATION HEAT TRANSFER FRO	71041	C.2-04
12600	D INVOLVING GAS INJECTION AND	VAPORIZATION= /F A POROUS SOLI	70052	C.2-03
04010	LITY OF A FEEDBACK CONTROLLED	VARIABLE CONDUCTANCE HEAT PIPE	71024	D.1-07
02501	S= FEEDBACK CONTROLLED	VARIABLE CONDUCTANCE HEAT PIPE	71027	D.1-08
09710	FABRICATION, AND TESTING OF A	VARIABLE CONDUCTANCE HEAT PIPE	71028	D.1-08
17710	FLIGHT EXPERIMENT= A	VARIABLE CONDUCTANCE HEAT PIPE	71038	E-11
16400	LLOYS WITH / COMPATIBILITY OF	VARIOUS HIGH-TEMP. HEAT PIPE A	68042	D.3-01
16101	IGATION OF THE PERFORMANCE OF	VARIOUS WICK CONFIGURATIONS IN	71030	E-09
06600	OWER ELECTRON TUBE IN A SPACE	VEHICLE= COOLING OF A HIGH P	69055	B.5-01
23810	AT PIPE APPLICATIONS TO SPACE	VEHICLES= HE	71013	B.3-10
09200	EXPERIMENTAL STUDY OF VAPOR	VELOCITY LIMIT IN A SODIUM HEA	69075	C.4-03
19510	ECTS OF FRICTION ON THE SONIC	VELOCITY LIMIT IN SODIUM HEAT	71022	C.4-05
31100	SFE/ HEAT PIPE - A UNIQUE AND	VERSATILE DEVICE FOR HEAT TRAN	67004	A-02
27000	STUDIES ON / DEVELOPMENT OF A	VERSATILE SYSTEM FOR DETAILED	69093	E-05
09902	IN A CRYOGENIC HEAT PIPE WITH	VERTICAL COUNTERCURRENT TWO-PH	70064	C.4-05
09910	HEAT TRANSFER COEFFICIENTS IN	VERTICAL TUBES FOR NITROGEN. H	71031	E-10
		*VERY * NOT INDEXED		
28401	A/ THE EFFECT OF LONGITUDINAL	VIBRATION ON HEAT PIPE PERFORM	70083	E-07
08200	ANCE= THE EFFECT OF	VIBRATION ON HEAT PIPE PERFORM	68043	E-02
16200	CHANNEL HEAT PIPE WICK=	VISCOUS FLOW IN A RECTANGULAR	66025	C.4-01
20001	ECHNOLOGY DEVELOPMENT OF HIGH	VOLTAGE MODULE= / THERMIONIC T	70013	B.2-12
20000	HNOLOGY - DEVELOPMENT OF HIGH	VOLTAGE MODULE= /HERMIONIC TEC	69015	B.2-09
28100	TO BLANKET DESIGN - A VACUUM	WALL FREE BLANKET USING HEAT P	70033	B.4-03
04600	IUM-1ZIRCONIUM OR TANTALUM AS	WALL MATERIAL= /IPES WITH NIOB	70079	D.3-03

12600	NG GA/ HEAT TRANSFER FROM THE	WALL OF A POROUS SOLID INVOLVI	70052	C.2-03
17900	OF HEAT EXCHANGE WITH BOILING	WATER DELIVERED TO THE HEATING	70057	C.3-02
25100	ENON / PERFORMANCE MAP OF THE	WATER HEAT PIPE AND THE PHENOM	69097	E-06
20800	ENTAL AND ANALYTICAL STUDY OF	WATER HEAT PIPES FOR MODERATE	69095	E-06
26900	F CAPILLARY ACTION IN BOILING	WATER HEAT TRANSFER THROUGH PO	70050	C.2-02
26700	RIMENTAL FEASIBILITY STUDY OF	WATER-FILLED CAPILLARY-PUMPED	66024	C.4-01
00500	R A HEATED HORIZONTAL TUBE IN	WATER-SATURATED WICK MATERIAL=	70056	C.2-03
27400	DESIGN OF A 50000	WATT HEAT PIPE SPACE RADIATOR=	69048	B.3-07
09700	MUNICATIONS WIT/ A MILLIMETER	WAVE PARABOLIC ANTENNA FOR COM	70027	B.3-09
09100	HEAT PIPES - A COOL	WAY TO COOL CIRCUITRY=	70038	B.5-02
		*WELL * NOT INDEXED		
27600	E FOR/ HEAT PIPE OVEN - A NEW	WELL-DEFINED METAL VAPOR DEVIC	69099	B.1-04
04100	VES= SURFACE	WETTING THROUGH CAPILLARY GROO	70059	C.3-02
15801	ITUDINA/ A STUDY OF WIRE MESH	WICK CHARACTERISTICS IN A LONG	70074	D.2-05
16101	OF THE PERFORMANCE OF VARIOUS	WICK CONFIGURATIONS IN SINGLE	71030	E-09
11000	ON HEAT TRANSFER FROM FLOODED	WICK COVERED SURFACES= /RIZATI	69070	C.3-02
17700	OF A LONGITUD/ THE EFFECT OF	WICK GEOMETRY ON THE OPERATION	70072	D.2-04
00500	ONTAL TUBE IN WATER-SATURATED	WICK MATERIAL= /A HEATED HORIZ	70056	C.2-03
12700	EXPERIMENTAL DETERMINATION OF	WICK PROPERTIES FOR HEAT PIPE	69087	D.2-03
11200	ON HEAT TRANSFER IN CAPILLARY	WICK STRUCTURES= VAPORIZATI	69067	C.2-02
06000	PERFORMANCE OF A	WICK-LIMITED HEAT PIPE=	69089	D.2-04
00400	ON HEAT TRANSFER FROM FLOODED	WICK= VAPORIZATI	71041	C.2-04
16200	RECTANGULAR CHANNEL HEAT PIPE	WICK= VISCOUS FLOW IN A	66025	C.4-01
07000	N THE/ THE ROLES OF CAPILLARY	WICKING AND SURFACE DEPOSITS I	64002	C.2-01
18400	NSFER PROPERTIES OF HEAT PIPE	WICKING MATERIALS= /D HEAT TRA	71044	D.2-06
18500	PROPERTIES OF SOME HEAT PIPE	WICKING MATERIALS= / TRANSPORT	69090	D.2-04
10000	IBLE MATERI/ DETERMINATION OF	WICKING PROPERTIES OF COMPRESS	69086	D.2-03
10100	IBLE MATERIALS F/ DETERMINING	WICKING PROPERTIES OF COMPRESS	68039	D.2-03
07100	COOLANT SUPPLIED BY CAPILLARY	WICKING= / FOR A SURFACE WITH	63001	C.2-01
07901	N AND OPERATION OF A ROTATING	WICKLESS HEAT PIPE= /TAL DESIG	70085	E-08
13500	S/ THE ROTATING HEAT PIPE - A	WICKLESS HOLLOW SHAFT FOR TRAN	69081	D.1-04
20200	RE DISTRIBUTIONS IN HEAT PIPE	WICKS= ANALYSIS OF TEMPERATU	69063	C.1-04
18100	ND BOILING CHARACTERISTICS OF	WICKS= /TRANSPORT PROPERTIES A	67053	D.2-02
26600	ATURATED SINTERED FIBER METAL	WICKS= /TY OF DRY AND LIQUID-S	70054	C.2-03
15801	IN A LONGITUDINA/ A STUDY OF	WIRE MESH WICK CHARACTERISTICS	70074	D.2-05
		*WITH * NOT INDEXED		
04000	E ABSORPTION CESIUM RESERVOIR	WORKING AT COLLECTOR TEMPERATU	68014	B.2-08
03800	ENTS USING A SODIUM HEAT PIPE	WORKING AT LOW VAPOR PRESSURE=	68027	C.2-01
16400	H-TEMP. HEAT PIPE ALLOYS WITH	WORKING FLUIDS= /F VARIOUS HIG	68042	D.3-01
10400	ND ANALYSIS=	WORKSHOP ON HEAT PIPE DESIGN A	68038	D.1-04
03100	E OF 4/ THE VAPOR PRESSURE OF	YTTERBIUM IN THE PRESSURE RANG	67011	B.1-02
08700	HEAT PIPE PERFORMANCE IN A	ZERO-G GRAVITY FIELD=	68050	E-04
10800	AT TRANSFER IN THE EVAPORATOR	ZONE OF A HEAT PIPE= /SM OF HE	70061	C.3-03
23600	Y= DESIGN OF A	1 KWE FAST REACTOR POWER SUPPL	67033	B.4-01
22600	FOR S/ CONCEPTUAL DESIGN OF A	10-MWE NUCLEAR RANKINE SYSTEM	70029	B.3-09
05400	E TESTS AT 1600 DEGREES C AND	1000 DEGREES C= HEAT PIPE LIF	68055	E-05
16600	ID METAL HEAT PIPE SYSTEMS AT	1000 TO 1800C= /TUDIES OF LIQU	70075	D.3-02
05400	S C= HEAT PIPE LIFE TESTS AT	1600 DEGREES C AND 1000 DEGREE	68055	E-05
16600	HEAT PIPE SYSTEMS AT 1000 TO	1800C= /TUDIES OF LIQUID METAL	70075	D.3-02
28900	HIGH POWER GRIDDED TUBES -	1968=	68024	B.5-01
12701	HNOLOGY - TOPICAL REPORT TASK	2 - DEVELOPMENT OF ADSORPTION	70017	B.2-13
22601	C SPA/ CONCEPTUAL DESIGN OF A	2-MWT (375KWE) NUCLEAR-ELECTRI	71015	B.4-04
12200	POR MPD / EXPERIMENTS USING A	25KW HOLLOW CATHODE LITHIUM VA	69007	B.1-03
04001	ERMIONIC/ A DESIGN STUDY OF A	350 KWE OUT-OF-CORE NUCLEAR TH	70011	B.2-12

03100	BIUM IN THE PRESSURE RANGE OF 40 TO 400 TORR= /SURE OF YTTER	67011	B.1-02
03100	N THE PRESSURE RANGE OF 40 TO 400 TORR= /SURE OF YTTERBIUM I	67011	B.1-02
03200	N THE PRESSURE RANGE OF 50 TO 4000 TORR= /DIFFERENT METALS I	67010	B.1-02
28800	HEAT PIPE EXPERIMENT FOR THE 5E-4 SATELLITE= / CONTROLLABLE	65016	E-01
03200	TALS IN THE PRESSURE RANGE OF 50 TO 4000 TORR= /DIFFERENT ME	67010	B.1-02
28200	ADIATOR FOR SPACE POWER FOR A 50-MWT SPACE POWER PLANTS= / R	67031	B.3-02
27400	IATOR= DESIGN OF A 50000 WATT HEAT PIPE SPACE RAD	69048	B.3-07

F.3 AUTHOR INDEX

00010	ABU-ROMIA M	71021 C.4-05
00100	ACHENER P Y	67056 D.3-01
00200	ACHENER P Y	67057 D.3-01
00300	ADT R R JR	70060 C.3-02
00301	ALBACH C R	71004 B.1-05
00400	ALLEAVITCH J	71041 C.2-04
11000	ALLEAVITCH J	69070 C.3-02
11200	ALLEAVITCH J	69067 C.2-02
00500	ALLINGHAM WM D	70056 C.2-03
00600	ALTIERI D	71042 B.3-11
01000	ANAND D K	68017 B.3-03
00700	ANAND D K	66022 C.2-01
00900	ANAND D K	67040 C.3-01
00800	ANAND D K	69046 B.3-07
01100	ANDEEN G B	66023 C.4-01
01200	ANDERSON J L	69014 B.2-08
01300	ANDERSON J L	68012 B.2-07
12500	ANDERSON R C	68009 B.2-07
01400	ARCELLA F G	69003 A-03
09200	ARCELLA F G	69075 C.4-03
01500	ARMAND M	69061 C.1-03
26200	ARMAND M	70004 A-04
14900	AUER B M	66017 C.1-01
01600	BAEHR A	69072 C.4-02
01700	BAINES W D	50001 C.4-01
01800	BAINTON K F	71045 E-11
20501	BALLBACK L J	70043 C.1-05
12900	BARKER V A	69074 C.4-03
18200	BARNES J F	68047 E-03
01900	BARNETT C S	67018 B.2-05
01901	BARSCH W O	71001 A-04
02000	BASIULIS A	69054 B.5-01
02100	BASIULIS A	69058 B.5-02
02300	BASIULIS A	68008 B.1-03
02200	BASIULIS A	70030 B.3-09
02201	BASIULIS A	71036 E-10
06500	BEGGS J E	69056 B.5-01
26101	BENTILLA E W	66014 B.3-01
26600	BERENSON P J	70054 C.2-03
02600	BIENERT W	69010 B.1-04
02501	BIENERT W B	71027 D.1-08
02400	BIENERT W B	69052 B.4-02
02500	BIENERT W B	68011 B.2-07
02601	BILENAS J A	70069 D.1-06
12200	BLACKSTOCK A W	69007 B.1-03
02700	BLISS F E JR	70086 E-08
03000	BOHDANSKY J	65005 B.1-01
03100	BOHDANSKY J	67011 B.1-02
02900	BOHDANSKY J	67012 B.1-02
02800	BOHDANSKY J	69027 B.2-12
02801	BOHDANSKY J	71009 B.2-15
04000	BOHDANSKY J	68014 B.2-08
03900	BOHDANSKY J	69024 B.2-11
03300	BOHDANSKY J	67009 B.1-02

03200	BOHDANSKY J	67010 B.1-02
03600	BOHDANSKY J	66015 B.3-01
03800	BOHDANSKY J	68027 C.2-01
03700	BOHDANSKY J	68020 B.4-01
03500	BOHDANSKY J	67023 B.2-06
03400	BOHDANSKY J	68007 B.1-03
14100	BOHDANSKY J	67024 B.2-06
14000	BOHDANSKY J	67019 B.2-05
08000	BRABERS M J	69022 B.2-10
04001	BREITWIESER R	70011 B.2-12
04004	BREITWIESER R	71005 B.2-14
04010	BRENNAN P J	71024 D.1-07
02501	BRENNAN P J	71027 D.1-08
04100	BRESSLER R G	70059 C.3-02
04200	BROSENS P	68044 E-03
04300	BROSENS P	67017 B.2-05
04400	BROSENS P	67022 B.2-06
20700	BROWN N J	69045 B.3-07
16100	BURCK E	69078 C.4-04
01600	BURCK E	69072 C.4-02
04401	BURGES R T	68053 E-04
09100	BURKE M R	70038 B.5-02
09000	BURKE M R	69059 B.5-02
03700	BUSSE C A	68020 B.4-01
13901	BUSSE C A	69028 B.2-12
14000	BUSSE C A	67019 B.2-05
04600	BUSSE C A	70079 D.3-03
04500	BUSSE C A	70053 C.2-03
04700	BUSSE C A	69060 C.1-03
14100	BUSSE C A	67024 B.2-06
04900	BUSSE C A	66003 B.2-02
04800	BUSSE C A	69025 B.2-11
05000	BUSSE C A	67042 C.4-02
05100	BUSSE C A	65011 B.2-02
05400	BUSSE C A	68055 E-05
05300	BUSSE C A	69092 D.3-01
05200	BUSSE C A	66027 D.1-01
05401	BYRD A W	71008 B.2-14
26101	CAFARO C	66014 B.3-01
13800	CAHILL J A	67007 B.1-01
05500	CALIMBAS A T	69043 B.3-07
05600	CALIMBAS A T	69042 B.3-06
05700	CAMPANA R J	64003 D.1-01
05100	CAPPELLETTI C	65011 B.2-02
05800	CARLSON G	67047 D.1-02
05801	CARLSON G A	70045 C.1-05
28200	CARLSON G A	67031 B.3-02
28300	CARLSON G A	69044 B.3-07
05900	CARNESALE A	67035 C.1-02
06900	CARNESALE A	67038 C.1-02
11400	CARNESALE A	67041 C.4-02
11300	CARNESALE A	67059 E-02
11500	CARNESALE A	67036 C.1-02
05200	CARON R	66027 D.1-01

05100	CARON R	65011	B.2-02
23700	CARTER R P	69033	B.3-04
05901	CASAZZA S A	70039	B.5-02
06000	CHATO J C	69089	D.2-04
16101	CHATO J C	71030	E-09
27000	CHATO J C	69093	E-05
06100	CHERKASSKII A KH	70036	B.4-03
06300	CHEUNG H	68002	A-02
06200	CHEUNG H	67048	D.1-02
06301	CHI S W	71019	C.1-06
06400	CHI S W	70071	D.1-07
19501	CHOU S	70062	C.4-04
02700	CLARK E G JR	70086	E-08
06410	CLAUSEN O W	71023	D.1-07
06401	COLWELL G T	71020	C.4-05
06500	CONWAY E C	69056	B.5-01
06600	CONWAY E C	69055	B.5-01
06700	CONWAY E C	68036	D.1-03
27600	COOPER J	69099	B.1-04
13901	CORON R J	69028	B.2-12
06800	COSGROVE J H	68035	D.1-03
05900	COSGROVE J H	67035	C.1-02
06900	COSGROVE J H	67038	C.1-02
07100	COSTELLO C P	63001	C.2-01
07000	COSTELLO C P	64002	C.2-01
07200	COTTER T P	68046	E-03
07300	COTTER T P	67034	C.1-02
07500	COTTER T P	66031	E-01
14200	COTTER T P	64001	C.2-01
07400	COTTER T P	65001	A-01
23700	CROKE E J	69033	B.3-04
23800	CROKE E J	69051	B.4-02
23600	CROKE E J	67033	B.4-01
07501	CROUTHAMEL T A	70010	B.1-05
06400	CYGNAROWICZ T A	70071	D.1-07
07600	CYGNAROWICZ T A	70009	B.1-05
07501	CYGNAROWICZ T A	70010	B.1-05
07700	DAGBJARTSSON S	69019	B.2-10
23900	DAGBJARTSSON S	66010	B.2-03
07701	DAILEY C C	71016	B.5-03
07901	DALEY T J	70085	E-08
20501	DALEY T J	70043	C.1-05
07800	DALLAS D B	68003	A-02
07900	DAY W R	69030	B.3-04
08000	DE TROYER A	69022	B.2-10
08000	DEJONGHE P	69022	B.2-10
08001	DEVAN J H	71034	E-10
07500	DEVERALL J	66031	E-01
08300	DEVERALL J E	65015	E-01
08501	DEVERALL J E	71032	E-10
08200	DEVERALL J E	68043	E-02
08400	DEVERALL J E	70076	D.3-02
08800	DEVERALL J E	67030	B.3-02
08600	DEVERALL J E	68045	E-03

08100	DEVERALL J E	68005	B.1-02
08700	DEVERALL J E	68050	E-04
08500	DEVERALL J E	65012	B.3-01
16100	DICOLA G	69078	C.4-04
02000	DIXON J C	69054	B.5-01
02100	DIXON J C	69058	B.5-02
08900	DORNER S	67055	D.2-02
09000	DUTCHER C H	69059	B.5-02
09100	DUTCHER C H JR	70038	B.5-02
00900	DYBBS A Z	67040	C.3-01
09200	DZAKOWIC G S	69075	C.4-03
01400	DZAKOWIC G S	69003	A-03
09500	EASTMAN G Y	67015	B.2-04
09300	EASTMAN G Y	69004	A-03
09400	EASTMAN G Y	68001	A-02
12800	EASTMAN G Y	66012	B.2-04
09900	EASTMAN G Y	68006	B.1-03
09600	EASTMAN G Y	70005	A-04
19900	EASTMAN G Y	69029	B.2-12
15200	EASTMAN G Y	71043	B.1-05
09700	EBY R J	70027	B.3-09
09710	EDELSTEIN F	71028	D.1-08
09701	EGGERS P E	71025	D.1-07
14200	ERICKSON G F	64001	C.2-01
07500	ERICKSON G F	66031	E-01
09800	ERNST D M	67037	C.1-02
09500	ERNST D M	67015	B.2-04
09900	ERNST D M	68006	B.1-03
09901	ERNST D M	69018	B.2-09
25600	ERNST D M	69026	B.2-11
09910	EWALD R	71031	E-10
09902	EWALD R	70064	C.4-05
09903	EWERS B J	70012	B.2-12
09920	FACKLER W C	71035	E-10
10100	FARRAN R A	68039	D.2-03
10000	FARRAN R A	69086	D.2-03
10700	FELDMAN K T	67006	A-02
10600	FELDMAN K T	69096	E-06
10400	FELDMAN K T	68038	D.1-04
10500	FELDMAN K T	69001	A-02
10300	FELDMAN K T JR	70001	A-04
10200	FELDMAN K T JR	70068	D.1-06
11600	FERRELL J K	68048	E-03
06900	FERRELL J K	67038	C.1-02
11200	FERRELL J K	69067	C.2-02
11000	FERRELL J K	69070	C.3-02
10800	FERRELL J K	70061	C.3-03
11300	FERRELL J K	67059	E-02
11700	FERRELL J K	68029	C.3-01
11500	FERRELL J K	67036	C.1-02
05900	FERRELL J K	67035	C.1-02
10900	FERRELL J K	69065	C.1-04
11400	FERRELL J K	67041	C.4-02
11800	FERRELL J K	68049	E-03

11100	FERRELL J K	70051	C.2-02
11900	FIEBELMANN P	69082	D.1-05
12000	FIEBELMANN P	69020	B.2-10
02201	FILLER M	71036	E-10
21500	FILLINNOV Y N	70006	A-04
12100	FLAHERTY R	70014	B.2-13
20400	FLEISCHMAN G L	70087	E-08
08501	FLORSCHUETZ L W	71032	E-10
12101	FORMAN R	71003	B.1-05
26501	FORMAN R	71029	E-09
12200	FRADKIN D B	69007	B.1-03
02500	FRANK S	68011	B.2-07
12300	FRANK S	68037	D.1-03
12400	FRANK S	67046	D.1-02
12500	FRANK T G	68009	B.2-07
12600	FREA W J	70052	C.2-03
07000	FREA W J	64002	C.2-01
12701	FREGGENS R A	70017	B.2-13
12700	FREGGENS R A	69087	D.2-03
23900	FRITZ R	66010	B.2-03
12800	FRYSINGER G R	66012	B.2-04
12900	GALOWIN L S	69074	C.4-03
08000	GAMMEL G	69022	B.2-10
05400	GEIGER F	68055	E-05
05200	GEIGER F	66027	D.1-01
05300	GEIGER F	69092	D.3-01
13101	GERRELS E E	71011	B.3-10
13200	GILLOT R H	67021	B.2-06
09700	GOLDBERG G I	70027	B.3-09
13300	GRAUMANN D W	67051	D.2-02
13400	GRAUMANN D W	67054	D.2-02
26600	GRAUMANN D W	70054	C.2-03
13500	GRAY V H	69081	D.1-04
13501	GREGORY F C	70058	C.3-02
01100	GRIFFITH P	66023	C.4-01
13600	GRITTON E C	70018	B.2-13
13700	GROLL M	70047	C.1-05
07700	GROLL M	69019	B.2-10
13701	GROLL M	70055	C.2-03
13702	GROLL M	70090	E-09
29001	GROLL M	71010	B.3-10
08000	GROSS F	69022	B.2-10
13800	GROSSE A V	67007	B.1-01
13901	GROVER G M	69028	B.2-12
13900	GROVER G M	66002	A-01
07500	GROVER G M	66031	E-01
03700	GROVER G M	68020	B.4-01
14300	GROVER G M	69028	B.2-12
14200	GROVER G M	64001	C.2-01
14100	GROVER G M	67024	B.2-06
14000	GROVER G M	67019	B.2-05
09500	HALL W B	67015	B.2-04
14400	HALL W B	66033	E-01
14501	HALL W B	65010	B.2-01

14500	HALL W B	67049 D.1-02
14503	HALL W B	66009 B.2-03
14502	HALL W B	66008 B.2-03
14700	HALLER H C	71040 B.3-11
14800	HALLER H C	65004 B.1-01
14900	HALLER H C	66017 C.1-01
14600	HALLER H C	65003 B.1-01
12600	HAMELINK J H	70052 C.2-03
15000	HAMPEL V E	69050 B.4-02
02500	HANNAH R	68011 B.2-07
22200	HANNAH R G	69041 B.3-06
22000	HANSON J P	67002 A-01
27400	HARBAUGH W E	69048 B.3-07
19900	HARBAUGH W E	69029 B.2-12
15300	HARBAUGH W E	68015 B.2-08
15104	HARBAUGH W E	66007 B.2-03
15103	HARBAUGH W E	66006 B.2-03
15102	HARBAUGH W E	65009 B.2-01
15200	HARBAUGH W E	71043 B.1-05
15101	HARBAUGH W E	65008 B.2-01
15100	HARBAUGH W E	65007 B.2-01
15400	HARKNESS R E	70080 E-07
15500	HARKNESS R E	69040 B.3-06
02601	HARWELL W	70069 D.1-06
15600	HASKIN W L	67044 D.1-01
15700	HEATH C A	68013 B.2-07
15800	HEATH C A	68010 B.2-07
09710	HEMBACH R J	71028 D.1-08
01000	HESTER R B	68017 B.3-03
15801	HICKOX O J	70074 D.2-05
18600	HILTON B H	66029 D.2-01
18700	HILTON B H	66030 D.2-01
18100	HILTON B H	67053 D.2-02
22400	HINDERMAN J D	69088 D.2-04
15900	HINDERMAN J D	69037 B.3-05
15901	HINDERMAN J D	71026 D.1-07
05801	HOFFMAN M A	70045 C.1-05
16100	HOFFMANN H	69078 C.4-04
05700	HOLLAND J W	64003 D.1-01
15910	HOLM F W	71018 C.1-06
21000	HOLM F W	70041 C.1-04
16000	HOLM F W	70046 C.1-05
21001	HOLM F W	70042 C.1-04
26800	HOLMGREN J S	69035 B.3-05
22500	HOLMGREN J S	68054 E-05
16001	HOLMGREN J S	70081 E-07
06401	HSU J C	71020 C.4-05
20200	HUANG Y S	69063 C.1-04
16100	HUFSCHMIDT W	69078 C.4-04
01600	HUFSCHMIDT W	69072 C.4-02
05500	HULETT R H	69043 B.3-07
05600	HULETT R H	69042 B.3-06
16101	HUNSBERGER D L	71030 E-09
27100	INGRAM E H	69034 B.3-04

16110	IVANOVSKII M N	71033	E-10
08001	JANSEN D H	71034	E-10
16200	JANSSEN M	66025	C.4-01
16300	JEFFERIES N P	67032	B.3-03
00900	JENKINS R E	67040	C.3-01
05901	JOACHIM R J	70039	B.5-02
16600	JOHNSON G D	70075	D.3-02
16400	JOHNSON G D	68042	D.3-01
10800	JOHNSON H R	70061	C.3-03
11100	JOHNSON H R	70051	C.2-02
16700	JOY P	70067	D.1-06
16800	JUDGE J F	66032	E-01
16801	KALKBRENNER R W	70003	A-04
15901	KASER R V	71026	D.1-07
16900	KATZOFF S	67045	D.1-02
17000	KATZOFF S	67028	B.3-02
07500	KEDDY E S	66031	E-01
14300	KEDDY E S	69028	B.2-12
06500	KELLEY M J	69056	B.5-01
06700	KELLEY M J	68036	D.1-03
21601	KELLY A J	70084	E-08
23100	KEMME J E	66001	A-01
17400	KEMME J E	68040	D.2-03
17100	KEMME J E	67052	D.2-02
17600	KEMME J E	69073	C.4-03
17200	KEMME J E	67050	D.2-01
17500	KEMME J E	69084	D.1-05
17300	KEMME J E	68026	C.1-03
14300	KEMME J E	69028	B.2-12
08300	KEMME J E	65015	E-01
08501	KEMME J E	71032	E-10
07500	KEMME J E	66031	E-01
08500	KEMME J E	65012	B.3-01
01100	KERN F R	66023	C.4-01
14502	KESSLER S W	66008	B.2-03
14503	KESSLER S W	66009	B.2-03
14501	KESSLER S W	65010	B.2-01
14500	KESSLER S W	67049	D.1-02
17700	KILMARTIN H E JR	70072	D.2-04
27700	KING P P	70078	D.3-02
17710	KIRKPATRICK J P	71038	E-11
02501	KIRKPATRICK J P	71027	D.1-08
08800	KNAPP R J	67030	B.3-02
08700	KNAPP R J	68050	E-04
17800	KOEPPE A	68023	B.4-02
17900	KOLACH T A	70057	C.3-02
15000	KOOPMAN R P	69050	B.4-02
08000	KOSKINEN M F	69022	B.2-10
17910	KOSOWSKI N	71037	E-11
17910	KOSSON R	71037	E-11
05300	KRAFT G	69092	D.3-01
17901	KROEGER E W	71006	B.2-14
18000	KUCHEROV R Y	60001	C.3-01
18500	KUNZ H R	69090	D.2-04

18100	KUNZ H R	67053	D.2-02
18400	KUNZ H R	71044	D.2-06
18200	KUNZ H R	68047	E-03
18300	KUNZ H R	66028	D.2-01
18201	KUO S C Y	70019	B.2-14
09902	LACAZE A	70064	C.4-05
08000	LANGPAPE R	69022	B.2-10
18300	LANGSTON L	66028	D.2-01
18500	LANGSTON L S	69090	D.2-04
18700	LANGSTON L S	66030	D.2-01
18600	LANGSTON L S	66029	D.2-01
18400	LANGSTON L S	71044	D.2-06
18100	LANGSTON L S	67053	D.2-02
21910	LANTZ E	71014	B.4-04
04001	LANTZ E	70011	B.2-12
15800	LANTZ E	68010	B.2-07
15700	LANTZ E	68013	B.2-07
01200	LANTZ E	69014	B.2-08
01300	LANTZ E	68012	B.2-07
18800	LARKIN B S	68030	C.4-02
13101	LARSON J W	71011	B.3-10
18900	LAUB J H	62001	C.4-01
19000	LAZARIDIS L J	67025	B.2-06
19100	LEE J D	69053	B.4-03
19200	LEE J D	69049	B.4-02
19300	LEEFER B I	66013	B.2-04
19401	LEVEDAHL W J	70015	B.2-13
02400	LEVEDAHL W J	69052	B.4-02
09901	LEVY E K	69018	B.2-09
19501	LEVY E K	70062	C.4-04
19510	LEVY E K	71022	C.4-05
19500	LEVY E K	69071	C.4-02
14700	LIEBLEIN S	71040	B.3-11
14800	LIEBLEIN S	65004	B.1-01
12200	LIEWER K W	69007	B.1-03
14800	LINDOW B G	65004	B.1-01
14900	LINDOW B G	66017	C.1-01
19600	LOEWE W E	69012	B.2-08
19700	LOEWE W E	69017	B.2-09
19800	LOEWE W E	69021	B.2-10
20001	LONGSDERFF R W	70013	B.2-12
19900	LONGSDERFF R W	69029	B.2-12
20000	LONGSDERFF R W	69015	B.2-09
15300	LONGSDERFF R W	68015	B.2-08
20100	LOPER O J	69009	B.1-04
07900	LUCHSINGER T H	69030	B.3-04
20200	LYMAN F A	69063	C.1-04
15900	MADSEN J	69037	B.3-05
07600	MALONEY J A	70009	B.1-05
06410	MARCUS B D	71023	D.1-07
20400	MARCUS B D	70087	E-08
20500	MARCUS B D	65002	A-01
17710	MARCUS B D	71038	E-11
20600	MARTO P J	69069	C.3-01

20501	MARTO P J	70043	C.1-05
20700	MCCAULEY E W	69045	B.3-07
00500	MCENTIRE J A	70056	C.2-03
18900	MCGINNESS H D	62001	C.4-01
20800	MCKINNEY B G	69095	E-06
20900	MCSWEENEY T I	70082	E-07
27101	MEI S	70026	B.3-08
21700	MIHAIL A	67008	B.1-01
29000	MILLER N E	70034	B.4-03
21001	MILLER P L	70042	C.1-04
21000	MILLER P L	70041	C.1-04
16000	MILLER P L	70046	C.1-05
21100	MILLER P R JR	68019	B.3-03
21200	MILLERON N	69011	B.1-04
21300	MORITZ K	70048	C.1-06
21401	MORITZ K	70044	C.1-05
21400	MORITZ K	70049	C.1-06
22700	MORITZ K	67005	A-02
21500	MOSKVIN Y V	70006	A-04
21601	MOSS R A	70084	E-08
21600	MOSS R A	69098	E-06
20600	MOSTELLER W L	69069	C.3-01
21700	MOUSSEZ C	67008	B.1-01
18100	NASHICK G H	67053	D.2-02
18200	NASHICK G H	68047	E-03
21800	NEAL L G	68032	D.1-02
21901	NEU H	71002	A-05
21900	NEU H	66011	B.2-04
13200	NEU H	67021	B.2-06
12000	NEU H	69020	B.2-10
08000	NEVE DE MEVERGNIES E	69022	B.2-10
21910	NIEDERAUER G	71014	B.4-04
23700	NORCO J E	69033	B.3-04
19000	PANTAZELOS P G	67025	B.2-06
22000	PARKER G H	67002	A-01
00600	PARKER J JR	71042	B.3-11
28000	PATRICK A J	70008	B.1-05
22100	PEDERSEN E S	67026	B.2-07
09910	PERROUD P	71031	E-10
09902	PERROUD P	70064	C.4-05
02500	PETERS J T	68011	B.2-07
22200	PETERS J T	69041	B.3-06
01700	PETERSON E G	50001	C.4-01
22500	PHILLIPS E C	68054	E-05
22400	PHILLIPS E C	69088	D.2-04
22300	PHILLIPS E C	69094	E-05
13600	PINKEL B	70018	B.2-13
06410	PISKE W E	71023	D.1-07
22601	PITTS J H	71015	B.4-04
22600	PITTS J H	70029	B.3-09
05300	POETZSCHKE M	69092	D.3-01
05200	POETZSCHKE M	66027	D.1-01
05400	POETZSCHKE M	68055	E-05
21400	PRUSCHEK P	70049	C.1-06

22700	PRUSCHEK R	67005	A-02
07700	PRUSCHEK R	69019	B.2-10
22800	PUTHOFF R L	70022	B.3-08
22900	PUTHOFF R L	70024	B.3-08
23000	QUAST A	68028	C.3-01
05400	QUATAERT D	68055	E-05
28000	RANKEN W A	70008	B.1-05
23100	RANKEN W A	66001	A-01
23200	RANKEN W A	68021	B.4-01
07100	REDEKER E R	63001	C.2-01
23400	REICHLE L	70063	C.4-04
23401	REIMERS E	71017	B.5-03
23500	REISS F	69066	C.2-01
08900	REISS F	67055	D.2-02
28401	RICHARDSON J W	70083	E-07
18000	RIKENGLAZ L E	60001	C.3-01
12000	RINALDINI C	69020	B.2-10
23800	ROBERTS J J	69051	B.4-02
23700	ROBERTS J J	69033	B.3-04
23600	ROBERTS J J	67033	B.4-01
12200	ROEHLING D J	69007	B.1-03
23810	ROGOVIN J	71013	B.3-10
23810	ROUKIS J	71013	B.3-10
23820	ROUSAR D C	70025	B.3-08
23821	ROUSAR D C	70031	B.3-09
23900	RUEHLE R	66010	B.2-03
03500	SALAMON K	67023	B.2-06
08600	SALMI E W	68045	E-03
07500	SALMI E W	66031	E-01
08700	SALMI E W	68050	E-04
08800	SALMI E W	67030	B.3-02
24000	SALMI E W	67013	B.2-04
24700	SALMI E W	67016	B.2-05
24100	SAVAGE C J	70021	B.3-08
24200	SCHACH M	70023	B.3-08
24300	SCHINDLER M	67039	C.2-01
22700	SCHINDLER M	67005	A-02
24400	SCHINS H E J	68041	D.3-01
03400	SCHINS H E J	68007	B.1-03
03300	SCHINS H E J	67009	B.1-02
03600	SCHINS H E J	66015	B.3-01
03200	SCHINS H E J	67010	B.1-02
03000	SCHINS H E J	65005	B.1-01
03100	SCHINS H E J	67011	B.1-02
02900	SCHINS H E J	67012	B.1-02
07700	SCHLOERB O	69019	B.2-10
24600	SCHMIDT E	69079	D.1-04
24500	SCHMIDT E	69077	C.4-04
25200	SCHMIDT E	67020	B.2-05
25300	SCHMIDT E	69064	C.1-04
01901	SCHOENHALS R J	71001	A-04
24700	SCHREIBER R E	67016	B.2-05
23500	SCHRETZMANN K	69066	C.2-01
08900	SCHRETZMANN K	67055	D.2-02

24800	SCHULMAN F	67027	B.3-01
24900	SCHWARTZ J	70088	E-09
25100	SCHWARTZ J	69097	E-06
25000	SCHWARTZ J	69005	A-03
25110	SCOLLON T R JR	71012	B.3-10
25300	SEMERIA R	69064	C.1-04
25200	SEMERIA R	67020	B.2-05
24600	SEMERIA R	69079	D.1-04
09701	SERKIZ A W	71025	D.1-07
25400	SEROV A	70028	B.3-09
25600	SHEFSIEK P K	69026	B.2-11
25500	SHEFSIEK P K	67060	E-02
09901	SHEFSIEK P K	69018	B.2-09
07501	SHELPUK B	70010	B.1-05
25601	SHELTON R D	70002	A-04
25700	SHEPPARD T D JR	69057	B.5-01
18700	SHERMAN A	66030	D.2-01
18600	SHERMAN A	66029	D.2-01
25400	SHISHINA V	70028	B.3-09
26100	SHLOSINGER A P	68016	B.3-03
26101	SHLOSINGER A P	66014	B.3-01
26000	SHLOSINGER A P	69032	B.3-04
25800	SHLOSINGER A P	69047	B.3-07
25900	SHLOSINGER A P	69038	B.3-06
26200	SHROFF A M	70004	A-04
01500	SHROFF A M	69061	C.1-03
16110	SHUSTOV M V	71033	E-10
26500	SILVERSTEIN C C	68004	B.1-02
26300	SILVERSTEIN C C	70020	B.3-07
22900	SILVERSTEIN C C	70024	B.3-08
26400	SILVERSTEIN C C	69008	B.1-03
12300	SMITH J T	68037	D.1-03
26501	SOCKOL P M	71029	E-09
26600	SOLIMAN M M	70054	C.2-03
16110	SOROKIN V P	71033	E-10
10000	STARNER K E	69086	D.2-03
10100	STARNER K E	68039	D.2-03
02300	STARR M C	68008	B.1-03
02700	STEIN B	70086	E-08
23900	STEINER D	66010	B.2-03
26700	STENGER F J	66024	C.4-01
26800	STEPHANOU S E	69035	B.3-05
26900	STRATTON A A	70050	C.2-02
12200	STRATTON T F	69007	B.1-03
02400	STREB A J	69052	B.4-02
06000	STRECKERT J H	69089	D.2-04
27000	STRECKERT J H	69093	E-05
05300	STRUB H	69092	D.3-01
03800	STRUB H	68027	C.2-01
16110	SUBBOTIN V I	71033	E-10
23200	SUMMERS C S	68021	B.4-01
23810	SWERDLING B	71013	B.3-10
09200	TANG Y S	69075	C.4-03
12300	TAYLOR K M	68037	D.1-03

G. HEAT PIPE RELATED PATENTS

G.1 PATENTS

HEAT PIPE RELATED PATENTS

00100 GAY F W
COOLING SYSTEM FOR UNDERGROUND ELECTRIC TRANSMISSION LINES
U.S. PATENT 1754314
APRIL 15, 1930

00200 BISSELL R E
COOLING CAPSULE FILLED VALVE
U.S. PATENT 1786285
DEC 23, 1930

00300 SCHLUMBOHM P
METHOD OF COOLING INDIRECTLY
U.S. PATENT 1975868
OCT 9, 1934

00400 HULSE G F
REFRIGERATION
U.S. PATENT 2010431
AUG 6, 1935

00500 FIENE M E
CONSTANT TEMPERATURE DEVICE
U.S. PATENT 2026423
DEC 31, 1935

00600 VERNET S
CAR HEATER
U.S. PATENT 2028260
JAN 21, 1936

00700 BAILEY E G
LIQUID VAPORIZING TUBE
U.S. PATENT 2279548
APRIL 14, 1942

00800 GAUGLER R S
HEAT TRANSFER DEVICE
U.S. PATENT 2350348
JAN 6, 1944

00900 GAUGLER R S
CAPILLARY HEAT TRANSFER DEVICE FOR REFRIGERATION APPARATUS
U.S. PATENT 2448261
AUG 31, 1948

01000 STIVIN J
DISCHARGE DEVICE WITH AN OUTER ANODE
U.S. PATENT 2466565
APRIL 5, 1949

01100 GAUGLER R S
REFRIGERATING APPARATUS
U.S. PATENT 2517654
AUG 8, 1950

01200 BACKSTROM S M
ABSORPTION REFRIGERATION APPARATUS AND HEATING ARRANGEMENT
THEREFOR
U.S. PATENT 2581347
JAN 8, 1952

01300 NAREUTOVSKIH P
ELECTRICAL APPARATUS
U.S. PATENT 2711882
JUNE 28, 1955

01400 HOLM S
TEMPERATURE EQUALIZING MEANS FOR REGENERATIVE AIR PREHEATER
STRUCTURE
U.S. PATENT 2840351
JUNE 24, 1958

01500 NARBUT P
TRANSFORMER CONTROL APPARATUS
U.S. PATENT 2875263
FEB 24, 1959

01600 NARBUT P
ELECTRICAL APPARATUS
U.S. PATENT 2924635
FEB 9, 1960

01700 MASLIN A J ET AL
ELECTRICAL APPARATUS
U.S. PATENT 2961476
NOV 22, 1960

01800 EKELUND A E
TUBULAR FINNED METAL SECTIONS AND MANUFACTURE THEREOF
U.S. PATENT 2978797

APRIL 11, 1961

01900 STEELE R C
HEAT TRANSFER PANEL
U.S. PATENT 3018087
JAN 23, 1962

02000 SNELLING C D
FLUORESCENT LAMP FIXTURE
U.S. PATENT 3112890
DEC 3, 1963

02100 WYATT T
SATELLITE TEMPERATURE STABILIZATION SYSTEM
U.S. PATENT 3152774
OCT 13, 1964

02200 LONG E L
MEANS FOR MAINTAINING PERMAFROST FOUNDATIONS
U.S. PATENT 3217791
NOV 26, 1965

02300 RODGERS J S
STEAM CONDENSER OF THE WATER TUBE TYPE
U.S. PATENT 3217799
NOV 16, 1965

02400 TALCOTT R C
ELECTRON TUBE COMPRISING BERYLLIUM OXIDE CERAMIC
U.S. PATENT 3227905
JAN 4, 1966

02500 GROVER G M
EVAPORATION - CONDENSATION HEAT TRANSFER DEVICE
U.S. PATENT 3229759
JAN 18, 1966

02600 HEEREN H
INTERNALLY FINNED CONDENSER TUBE
U.S. PATENT 3273599
SEPT 20, 1966

02700 MCCORMICK H L
COOLED GAS TURBINE VANES

U.S. PATENT 3287906
NOV 29, 1966

02800 GROVER G M BOHDANSKY J
BUSSE C A
NUCLEAR REACTOR WITH THERMIONIC CONVERTER
U.S. PATENT 3302042
JAN 31, 1967

02900 GROVER G M ET AL
CAPILLARY INSERT FOR HEAT TUBES AND PROCESS FOR
MANUFACTURING SUCH INSERTS
U.S. PATENT 3305005
FEB 21, 1967

03000 MCDOUGAL J A
CARBURETOR COOLING MEANS
U.S. PATENT 3332476
JULY 25, 1967

03100 SCHRAITH E F ET AL
COOLING DEVICE FOR FLUORESCENT LAMPS
U.S. PATENT 3330130
JULY 11, 1967

03200 BOHDANSKY J BUSSE C A
GROVER G M
COOLING SYSTEM FOR NUCLEAR REACTORS
CANA PATENT 0765919
AUG 22, 1967

03300 NARBUT P
COOLING SYSTEM FOR ELECTRICAL APPARATUS
U.S. PATENT 3371298
FEB 27, 1968

03400 MILTON R M
HEAT EXCHANGE SYSTEM
U.S. PATENT 3384154
MAY 21, 1968

03500 CLINE R E
THERMAL SWITCH
U.S. PATENT 3399717
SEPT 3, 1968

03600 BOHDANSKY J ET AL
HEAT PIPES
U.S. PATENT 3402767
SEPT 24, 1968

03700 FIEBELMANN P
NUCLEAR REACTOR
U.S. PATENT 3403075
SEPT 24, 1968

03800 SWET C J
CONTROLLABLE HEAT PIPE APPARATUS
U.S. PATENT 3402761
SEPT 24, 1968

03900 HALL W B ET AL
VAPORIZABLE MEDIUM TYPE HEAT EXCHANGER FOR ELECTRON TUBES
U.S. PATENT 3405299
OCT 8, 1968

04000 ANAND D K
HEAT PIPE CONTROL APPARATUS
U.S. PATENT 3414050
DEC 3, 1968

04100 FIEBELMANN P
HEAT PIPES
U.S. PATENT 3414475
DEC 3, 1968

04200 BIENERT W B
HEAT PIPES FOR NON-WETTING FLUIDS
U.S. PATENT 3435889
APRIL 1, 1969

04300 RASPET D
CASCADED THERMIONIC - THERMOELECTRIC DEVICES UTILIZING HEAT
PIPES
U.S. PATENT 3437847
APRIL 8, 1969

04400 LEVEDAHL W J
HEAT PIPES WITH UNIQUE RADIATOR CONFIGURATION IN COMBINATION
WITH THERMIONIC CONVERTER
U.S. PATENT 3457436

JULY 22, 1969

04500 BIENERT W B LEVEDAHL W J
STREB A J
THERMAL CONTROL AND POWER FLATTENING FOR RADIOISOTOPIC THERMODYNAMIC POWER SYSTEM
BRIT PATENT 1160568
AUG 6, 1969

04600 BROMBERG R ET AL
METHOD OF AND MEANS FOR INCREASING THE HEAT TRANSFER CAPABILITY OF A HEAT PIPE
U.S. PATENT 3465813
SEPT 9, 1969

04700 LEVEDAHL W J
HEAT PIPES WITH PREFABRICATED GROOVED CAPILLARIES AND METHOD OF MAKING
U.S. PATENT 3498369
MAR 3, 1970

04800 LEVEDAHL W J
THERMIONIC CONVERTER ASSEMBLIES
BRIT PATENT 1182799
MAR 4, 1970

04900 SHLOSINGER A P
MEANS FOR REGULATING THERMAL ENERGY TRANSFER THROUGH A HEAT PIPE
U.S. PATENT 3502138
MAR 24, 1970

05000 BYRD A W
HEAT PIPE THERMIONIC DIODE POWER SYSTEM
U.S. PATENT 3509386
APRIL 28, 1970

05100 KEISER J T
HEAT PIPE WITH CONTROL
U.S. PATENT 3516487
JUNE 23, 1970

05200 WYATT T
CONTROLLABLE HEAT PIPE
U.S. PATENT 3517730

JUNE 30, 1970

05300 MILTON R M
HEAT EXCHANGE SYSTEM
U.S. PATENT 3523577
AUG 11, 1970

05400 LEVEDAHL W J
HEAT PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS
U.S. PATENT 3528494
SEPT 15, 1970

05500 HAMMITT A G BROADWELL J E
HIGH PERFORMANCE HEAT PIPE
U.S. PATENT 3532159
OCT 6, 1970

05600 BYRD A W
POWER SYSTEM WITH HEAT PIPE LIQUID COOLANT LINES
U.S. PATENT 3537515
NOV 3, 1970

05700 LEVEDAHL W J
HEAT PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS
U.S. PATENT 3537514
NOV 3, 1970

05800 EASTMAN G Y
HEAT EXCHANGER FOR HIGH VOLTAGE ELECTRONIC DEVICES
U.S. PATENT 3543841
DEC 1, 1970

06000 SHLOSINGER A P
MULTI-CHAMBER CONTROLLABLE HEAT PIPE
U.S. PATENT 3543839
DEC 1, 1970

06100 BYRD A W
ISOTHERMAL COVER WITH THERMAL RESERVOIRS
U.S. PATENT 3548930
DEC 22, 1970

G.2 SUBJECT INDEX

		'A ' NOT INDEXED
01200	ND HEATING ARRANGEMENT THEREFOR=	ABSORPTION REFRIGERATION APPARATUS A
01400	E EQUALIZING MEANS FOR REGENERATIVE	AIR PREHEATER STRUCTURE= TEMPERATUR
		'AN ' NOT INDEXED
		'AND ' NOT INDEXED
01000	DISCHARGE DEVICE WITH AN OUTER	ANODE=
01200	EREFOR= ABSORPTION REFRIGERATION	APPARATUS AND HEATING ARRANGEMENT TH
01100	REFRIGERATING	APPARATUS=
01300	ELECTRICAL	APPARATUS=
00900	T TRANSFER DEVICE FOR REFRIGERATION	APPARATUS= CAPILLARY HEA
04000	HEAT PIPE CONTROL	APPARATUS=
03800	CONTROLLABLE HEAT PIPE	APPARATUS=
03300	COOLING SYSTEM FOR ELECTRICAL	APPARATUS=
01700	ELECTRICAL	APPARATUS=
01600	ELECTRICAL	APPARATUS=
01500	TRANSFORMER CONTROL	APPARATUS=
01200	REFRIGERATION APPARATUS AND HEATING	ARRANGEMENT THEREFOR= ABSORPTION
04800	THERMIONIC CONVERTER	ASSEMBLIES=
02400	ELECTRON TUBE COMPRISING	BERYLLIUM OXIDE CERAMIC=
04600	NS FOR INCREASING THE HEAT TRANSFER	CAPABILITY OF A HEAT PIPE= / AND MEA
04700	AT PIPES WITH PREFABRICATED GROOVED	CAPILLARIES AND METHOD OF MAKING= /E
00900	EFRIGERATION APPARATUS=	CAPILLARY HEAT TRANSFER DEVICE FOR R
02900	PROCESS FOR MANUFACTURING SUCH INS/	CAPILLARY INSERT FOR HEAT TUBES AND
00200	COOLING	CAPSULE FILLED VALVE=
00600		CAR HEATER=
03000		CARBURETOR COOLING MEANS=
04300	DEVICES UTILIZING HEAT PIPES=	CASCADED THERMIONIC - THERMOELECTRIC
02400	RON TUBE COMPRISING BERYLLIUM OXIDE	CERAMIC= ELECT
06000	MULTI-	CHAMBER CONTROLLABLE HEAT PIPE=
04400	TH UNIQUE RADIATOR CONFIGURATION IN	COMBINATION WITH THERMIONIC CONVERTE
02400	ELECTRON TUBE	COMPRISING BERYLLIUM OXIDE CERAMIC=
02500	EVAPORATION -	CONDENSATION HEAT TRANSFER DEVICE=
02300	STEAM	CONDENSER OF THE WATER TUBE TYPE=
02600	INTERNALLY FINNED	CONDENSER TUBE=
05700	HEAT PIPE FOR LOW THERMAL	CONDUCTIVITY WORKING FLUIDS=
05400	HEAT PIPE FOR LOW THERMAL	CONDUCTIVITY WORKING FLUIDS=
04400	ER/ HEAT PIPES WITH UNIQUE RADIATOR	CONFIGURATION IN COMBINATION WITH TH
00500		CONSTANT TEMPERATURE DEVICE=
04500	IOISOTOPIC THERMODYNAMIC P/ THERMAL	CONTROL AND POWER FLATTENING FOR RAD
04000	HEAT PIPE	CONTROL APPARATUS=
01500	TRANSFORMER	CONTROL APPARATUS=
05100	HEAT PIPE WITH	CONTROL=
05200		CONTROLLABLE HEAT PIPE=
03800		CONTROLLABLE HEAT PIPE APPARATUS=
06000	MULTI-CHAMBER	CONTROLLABLE HEAT PIPE=
04800	THERMIONIC	CONVERTER ASSEMBLIES=
02800	NUCLEAR REACTOR WITH THERMIONIC	CONVERTER=
04400	TION IN COMBINATION WITH THERMIONIC	CONVERTER= /NIQUE RADIATOR CONFIGURA
05600	POWER SYSTEM WITH HEAT PIPE LIQUID	COOLANT LINES=
02700		COOLED GAS TURBINE VANES=
00200		COOLING CAPSULE FILLED VALVE=
03100	=	COOLING DEVICE FOR FLUORESCENT LAMPS
00300	METHOD OF	COOLING INDIRECTLY=
03000	CARBURETOR	COOLING MEANS=

03300	TUS=	COOLING SYSTEM FOR ELECTRICAL APPARA	
03200		COOLING SYSTEM FOR NUCLEAR REACTORS=	
00100	RIC TRANSMISSION LINES=	COOLING SYSTEM FOR UNDERGROUND ELECT	
06100	ISOTHERMAL	COVER WITH THERMAL RESERVOIRS=	
03100	COOLING	DEVICE FOR FLUORESCENT LAMPS=	
00900	CAPILLARY HEAT TRANSFER	DEVICE FOR REFRIGERATION APPARATUS=	
01000	DISCHARGE	DEVICE WITH AN OUTER ANODE=	
00800	HEAT TRANSFER	DEVICE=	
00500	CONSTANT TEMPERATURE	DEVICE=	
02500	RATION - CONDENSATION HEAT TRANSFER	DEVICE=	EVAPO
04300	ASCADED THERMIONIC - THERMOELECTRIC	DEVICES UTILIZING HEAT PIPES=	C
05800	CHANGER FOR HIGH VOLTAGE ELECTRONIC	DEVICES=	HEAT EX
05000	HEAT PIPE THERMIONIC	DIODE POWER SYSTEM=	
01000	=	DISCHARGE DEVICE WITH AN OUTER ANODE	
00100	COOLING SYSTEM FOR UNDERGROUND	ELECTRIC TRANSMISSION LINES=	
01300		ELECTRICAL APPARATUS=	
03300	COOLING SYSTEM FOR	ELECTRICAL APPARATUS=	
01600		ELECTRICAL APPARATUS=	
01700		ELECTRICAL APPARATUS=	
02400	XIDE CERAMIC=	ELECTRON TUBE COMPRISING BERYLLIUM O	
03900	ABLE MEDIUM TYPE HEAT EXCHANGER FOR	ELECTRON TUBES=	VAPORIZ
05800	HEAT EXCHANGER FOR HIGH VOLTAGE	ELECTRONIC DEVICES=	
04900	MEANS FOR REGULATING THERMAL	ENERGY TRANSFER THROUGH A HEAT PIPE=	
01400	R PREHEATER STRUCTURE= TEMPERATURE	EQUALIZING MEANS FOR REGENERATIVE AI	
02500	SFER DEVICE=	EVAPORATION - CONDENSATION HEAT TRAN	
05300	HEAT	EXCHANGE SYSTEM=	
03400	HEAT	EXCHANGE SYSTEM=	
03900	VAPORIZABLE MEDIUM TYPE HEAT	EXCHANGER FOR ELECTRON TUBES=	
05800	C DEVICES= HEAT	EXCHANGER FOR HIGH VOLTAGE ELECTRONI	
00200	COOLING CAPSULE	FILLED VALVE=	
02600	INTERNALLY	FINNED CONDENSER TUBE=	
01800	E THEREOF= TUBULAR	FINNED METAL SECTIONS AND MANUFACTUR	
02000	FLUORESCENT LAMP	FIXTURE=	
04500	YNAMIC P/ THERMAL CONTROL AND POWER	FLATTENING FOR RADIOISOTOPIC THERMOD	
05700	OR LOW THERMAL CONDUCTIVITY WORKING	FLUIDS=	HEAT PIPE F
05400	OR LOW THERMAL CONDUCTIVITY WORKING	FLUIDS=	HEAT PIPE F
04200	HEAT PIPES FOR NON-WETTING	FLUIDS=	
02000		FLUORESCENT LAMP FIXTURE=	
03100	COOLING DEVICE FOR	FLUORESCENT LAMPS=	
		*FOR * NOT INDEXED	
02200	MEANS FOR MAINTAINING PERMAFROST	FOUNDATIONS=	
02700	COOLED	GAS TURBINE VANES=	
04700	KING/ HEAT PIPES WITH PREFABRICATED	GROOVED CAPILLARIES AND METHOD OF MA	
05300		HEAT EXCHANGE SYSTEM=	
03400		HEAT EXCHANGE SYSTEM=	
03900	VAPORIZABLE MEDIUM TYPE	HEAT EXCHANGER FOR ELECTRON TUBES=	
05800	TRONIC DEVICES=	HEAT EXCHANGER FOR HIGH VOLTAGE ELEC	
03800	CONTROLLABLE	HEAT PIPE APPARATUS=	
04000		HEAT PIPE CONTROL APPARATUS=	
05400	TY WORKING FLUIDS=	HEAT PIPE FOR LOW THERMAL CONDUCTIVI	
05700	TY WORKING FLUIDS=	HEAT PIPE FOR LOW THERMAL CONDUCTIVI	
05600	POWER SYSTEM WITH	HEAT PIPE LIQUID COOLANT LINES=	
05000	TEM=	HEAT PIPE THERMIONIC DIODE POWER SYS	
05100		HEAT PIPE WITH CONTROL=	

05200	CONTROLLABLE	HEAT PIPE=
05500	HIGH PERFORMANCE	HEAT PIPE=
06000	MULTI-CHAMBER CONTROLLABLE	HEAT PIPE=
04900	G THERMAL ENERGY TRANSFER THROUGH A	HEAT PIPE= MEANS FOR REGULATIN
04600	G THE HEAT TRANSFER CAPABILITY OF A	HEAT PIPE= / AND MEANS FOR INCREASIN
04200		HEAT PIPES FOR NON-WETTING FLUIDS=
04700	D CAPILLARIES AND METHOD OF MAKING/	HEAT PIPES WITH PREFABRICATED GROOVE
04400	IGURATION IN COMBINATION WITH THER/	HEAT PIPES WITH UNIQUE RADIATOR CONF
04100		HEAT PIPES=
03600		HEAT PIPES=
04300	- THERMOELECTRIC DEVICES UTILIZING	HEAT PIPES= CASCADED THERMIONIC
04600	HOD OF AND MEANS FOR INCREASING THE	HEAT TRANSFER CAPABILITY OF A HEAT P
02500	EVAPORATION - CONDENSATION	HEAT TRANSFER DEVICE=
00800		HEAT TRANSFER DEVICE=
00900	ON APPARATUS= CAPILLARY	HEAT TRANSFER DEVICE FOR REFRIGERATI
01900		HEAT TRANSFER PANEL=
02900	RING SUCH INS/ CAPILLARY INSERT FOR	HEAT TUBES AND PROCESS FOR MANUFACTU
00600	CAR	HEATER=
01200	ORPTION REFRIGERATION APPARATUS AND	HEATING ARRANGEMENT THEREFOR= ABS
05500		HIGH PERFORMANCE HEAT PIPE=
05800	HEAT EXCHANGER FOR	HIGH VOLTAGE ELECTRONIC DEVICES=
		'IN ' NOT INDEXED
04600	ITY OF A H/ METHOD OF AND MEANS FOR	INCREASING THE HEAT TRANSFER CAPABIL
00300	METHOD OF COOLING	INDIRECTLY=
02900	R MANUFACTURING SUCH INS/ CAPILLARY	INSERT FOR HEAT TUBES AND PROCESS FO
02900	AND PROCESS FOR MANUFACTURING SUCH	INSERTS= /LARY INSERT FOR HEAT TUBES
02600		INTERNALLY FINNED CONDENSER TUBE=
06100	OIRS=	ISOTHERMAL COVER WITH THERMAL RESERV
02000	FLUORESCENT	LAMP FIXTURE=
03100	COOLING DEVICE FOR FLUORESCENT	LAMPS=
05600	YSTEM WITH HEAT PIPE LIQUID COOLANT	LINES= POWER S
00100	R UNDERGROUND ELECTRIC TRANSMISSION	LINES= COOLING SYSTEM FO
05600	POWER SYSTEM WITH HEAT PIPE	LIQUID COOLANT LINES=
00700		LIQUID VAPORIZING TUBE=
05700	IDS= HEAT PIPE FOR	LOW THERMAL CONDUCTIVITY WORKING FLU
05400	IDS= HEAT PIPE FOR	LOW THERMAL CONDUCTIVITY WORKING FLU
02200	MEANS FOR	MAINTAINING PERMAFROST FOUNDATIONS=
04700	D GROOVED CAPILLARIES AND METHOD OF	MAKING= /EAT PIPES WITH PREFABRICATE
01800	TUBULAR FINNED METAL SECTIONS AND	MANUFACTURE THEREOF=
02900	SERT FOR HEAT TUBES AND PROCESS FOR	MANUFACTURING SUCH INSERTS= /LARY IN
04600	ER CAPABILITY OF A H/ METHOD OF AND	MEANS FOR INCREASING THE HEAT TRANSF
02200	NOATIONS=	MEANS FOR MAINTAINING PERMAFROST FOU
01400	STRUCTURE= TEMPERATURE EQUALIZING	MEANS FOR REGENERATIVE AIR PREHEATER
04900	TRANSFER THROUGH A HEAT PIPE=	MEANS FOR REGULATING THERMAL ENERGY
03000	CARBURETOR COOLING	MEANS=
03900	RON TUBES= VAPORIZABLE	MEDIUM TYPE HEAT EXCHANGER FOR ELECT
01800	OF= TUBULAR FINNED	METAL SECTIONS AND MANUFACTURE THERE
04600	HE HEAT TRANSFER CAPABILITY OF A H/	METHOD OF AND MEANS FOR INCREASING T
00300		METHOD OF COOLING INDIRECTLY=
04700	EFABRICATED GROOVED CAPILLARIES AND	METHOD OF MAKING= /EAT PIPES WITH PR
06000	=	MULTI-CHAMBER CONTROLLABLE HEAT PIPE
04200	HEAT PIPES FOR	NON-WETTING FLUIDS=
02800	ERTER=	NUCLEAR REACTOR WITH THERMIONIC CONV
03700		NUCLEAR REACTOR=

03200	COOLING SYSTEM FOR	NUCLEAR REACTORS=
		*OF * NOT INDEXED
01000	DISCHARGE DEVICE WITH AN	OUTER ANODE=
02400	ELECTRON TUBE COMPRISING BERYLLIUM	OXIDE CERAMIC=
01900	HEAT TRANSFER	PANEL=
05500	HIGH	PERFORMANCE HEAT PIPE=
02200	MEANS FOR MAINTAINING	PERMAFROST FOUNDATIONS=
03800	CONTROLLABLE HEAT	PIPE APPARATUS=
04000	HEAT	PIPE CONTROL APPARATUS=
05400	RKING FLUIDS= HEAT	PIPE FOR LOW THERMAL CONDUCTIVITY WO
05700	RKING FLUIDS= HEAT	PIPE FOR LOW THERMAL CONDUCTIVITY WO
05600	POWER SYSTEM WITH HEAT	PIPE LIQUID COOLANT LINES=
05000	HEAT	PIPE THERMIONIC DIODE POWER SYSTEM=
05100	HEAT	PIPE WITH CONTROL=
05200	CONTROLLABLE HEAT	PIPE=
05500	HIGH PERFORMANCE HEAT	PIPE=
06000	MULTI-CHAMBER CONTROLLABLE HEAT	PIPE=
04900	RMAL ENERGY TRANSFER THROUGH A HEAT	PIPE= MEANS FOR REGULATING THE
04600	HEAT TRANSFER CAPABILITY OF A HEAT	PIPE= / AND MEANS FOR INCREASING THE
04200	HEAT	PIPES FOR NON-WETTING FLUIDS=
04700	ILLARIES AND METHOD OF MAKING/ HEAT	PIPES WITH PREFABRICATED GROOVED CAP
04400	TION IN COMBINATION WITH THER/ HEAT	PIPES WITH UNIQUE RADIATOR CONFIGURA
04100	HEAT	PIPES=
03600	HEAT	PIPES=
04300	ERMOELECTRIC DEVICES UTILIZING HEAT	PIPES= CASCADED THERMIONIC - TH
04500	HERMODYNAMIC P/ THERMAL CONTROL AND	POWER FLATTENING FOR RADIOISOTOPIC T
05600	OOLANT LINES=	POWER SYSTEM WITH HEAT PIPE LIQUID C
05000	HEAT PIPE THERMIONIC DIODE	POWER SYSTEM=
04500	ING FOR RADIOISOTOPIC THERMODYNAMIC	POWER SYSTEM= /ROL AND POWER FLATTEN
04700	D METHOD OF MAKING/ HEAT PIPES WITH	PREFABRICATED GROOVED CAPILLARIES AN
01400	UALIZING MEANS FOR REGENERATIVE AIR	PREHEATER STRUCTURE= TEMPERATURE EQ
02900	CAPILLARY INSERT FOR HEAT TUBES AND	PROCESS FOR MANUFACTURING SUCH INSER
04400	N WITH THER/ HEAT PIPES WITH UNIQUE	RADIATOR CONFIGURATION IN COMBINATIO
04500	AL CONTROL AND POWER FLATTENING FOR	RADIOISOTOPIC THERMODYNAMIC POWER SY
02800	NUCLEAR	REACTOR WITH THERMIONIC CONVERTER=
03700	NUCLEAR	REACTOR=
03200	COOLING SYSTEM FOR NUCLEAR	REACTORS=
01100		REFRIGERATING APPARATUS=
01200	ARRANGEMENT THEREFOR= ABSORPTION	REFRIGERATION APPARATUS AND HEATING
00900	CAPILLARY HEAT TRANSFER DEVICE FOR	REFRIGERATION APPARATUS=
00400		REFRIGERATION=
01400	= TEMPERATURE EQUALIZING MEANS FOR	REGENERATIVE AIR PREHEATER STRUCTURE
04900	HROUGH A HEAT PIPE= MEANS FOR	REGULATING THERMAL ENERGY TRANSFER T
06100	ISOTHERMAL COVER WITH THERMAL	RESERVOIRS=
02100	SYSTEM=	SATELLITE TEMPERATURE STABILIZATION
01800	TUBULAR FINNED METAL	SECTIONS AND MANUFACTURE THEREOF=
02100	SATELLITE TEMPERATURE	STABILIZATION SYSTEM=
02300	PE=	STEAM CONDENSER OF THE WATER TUBE TY
01400	EANS FOR REGENERATIVE AIR PREHEATER	STRUCTURE= TEMPERATURE EQUALIZING M
		*SUCH * NOT INDEXED
03500	THERMAL	SWITCH=
03300	COOLING	SYSTEM FOR ELECTRICAL APPARATUS=
03200	COOLING	SYSTEM FOR NUCLEAR REACTORS=
00100	SMISSION LINES= COOLING	SYSTEM FOR UNDERGROUND ELECTRIC TRAN

05600	LINES= POWER	SYSTEM WITH HEAT PIPE LIQUID COOLANT
03400	HEAT EXCHANGE	SYSTEM=
05000	HEAT PIPE THERMIONIC DIODE POWER	SYSTEM=
05300	HEAT EXCHANGE	SYSTEM=
02100	SATELLITE TEMPERATURE STABILIZATION	SYSTEM=
04500	R RADIOISOTOPIC THERMODYNAMIC POWER	SYSTEM= /ROL AND POWER FLATTENING FO
00500	CONSTANT	TEMPERATURE DEVICE=
01400	ENERATIVE AIR PREHEATER STRUCTURE=	TEMPERATURE EQUALIZING MEANS FOR REG
02100	SATELLITE	TEMPERATURE STABILIZATION SYSTEM=
		•THE • NOT INDEXED
01200	N APPARATUS AND HEATING ARRANGEMENT	THEREFOR= ABSORPTION REFRIGERATIO
01800	NNED METAL SECTIONS AND MANUFACTURE	THEREOF= TUBULAR FI
05700	HEAT PIPE FOR LOW	THERMAL CONDUCTIVITY WORKING FLUIDS=
05400	HEAT PIPE FOR LOW	THERMAL CONDUCTIVITY WORKING FLUIDS=
04500	FOR RADIOISOTOPIC THERMODYNAMIC P/	THERMAL CONTROL AND POWER FLATTENING
04900	AT PIPE= MEANS FOR REGULATING	THERMAL ENERGY TRANSFER THROUGH A HE
06100	ISOTHERMAL COVER WITH	THERMAL RESERVOIRS=
03500		THERMAL SWITCH=
04300	UTILIZING HEAT PIPES= CASCADED	THERMIONIC - THERMOELECTRIC DEVICES
04400	R CONFIGURATION IN COMBINATION WITH	THERMIONIC CONVERTER= /NIQUE RADIATO
02800	NUCLEAR REACTOR WITH	THERMIONIC CONVERTER=
04800		THERMIONIC CONVERTER ASSEMBLIES=
05000	HEAT PIPE	THERMIONIC DIODE POWER SYSTEM=
04500	POWER FLATTENING FOR RADIOISOTOPIC	THERMODYNAMIC POWER SYSTEM= /ROL AND
04300	T PIPES= CASCADED THERMIONIC -	THERMOELECTRIC DEVICES UTILIZING HEA
04900	REGULATING THERMAL ENERGY TRANSFER	THROUGH A HEAT PIPE= MEANS FOR
04600	F AND MEANS FOR INCREASING THE HEAT	TRANSFER CAPABILITY OF A HEAT PIPE= /
00900	PARATUS= CAPILLARY HEAT	TRANSFER DEVICE FOR REFRIGERATION AP
00800	HEAT	TRANSFER DEVICE=
02500	EVAPORATION - CONDENSATION HEAT	TRANSFER DEVICE=
01900	HEAT	TRANSFER PANEL=
04900	MEANS FOR REGULATING THERMAL ENERGY	TRANSFER THROUGH A HEAT PIPE=
01500		TRANSFORMER CONTROL APPARATUS=
00100	ING SYSTEM FOR UNDERGROUND ELECTRIC	TRANSMISSION LINES= COOL
02400	MIC= ELECTRON	TUBE COMPRISING BERYLLIUM OXIDE CERA
02300	STEAM CONDENSER OF THE WATER	TUBE TYPE=
02600	INTERNALLY FINNED CONDENSER	TUBE=
00700	LIQUID VAPORIZING	TUBE=
02900	SUCH INS/ CAPILLARY INSERT FOR HEAT	TUBES AND PROCESS FOR MANUFACTURING
03900	UM TYPE HEAT EXCHANGER FOR ELECTRON	TUBES= VAPORIZABLE MEDI
01800	NUFACTURE THEREOF=	TUBULAR FINNED METAL SECTIONS AND MA
02700	COOLED GAS	TURBINE VANES=
03900	ES= VAPORIZABLE MEDIUM	TYPE HEAT EXCHANGER FOR ELECTRON TUB
02300	STEAM CONDENSER OF THE WATER TUBE	TYPE=
00100	NES= COOLING SYSTEM FOR	UNDERGROUND ELECTRIC TRANSMISSION LI
04400	BINATION WITH THER/ HEAT PIPES WITH	UNIQUE RADIATOR CONFIGURATION IN COM
04300	THERMIONIC - THERMOELECTRIC DEVICES	UTILIZING HEAT PIPES= CASCADED
00200	COOLING CAPSULE FILLED	VALVE=
02700	COOLED GAS TURBINE	VANES=
03900	ER FOR ELECTRON TUBES=	VAPORIZABLE MEDIUM TYPE HEAT EXCHANG
00700	LIQUID	VAPORIZING TUBE=
05800	HEAT EXCHANGER FOR HIGH	VOLTAGE ELECTRONIC DEVICES=
02300	STEAM CONDENSER OF THE	WATER TUBE TYPE=
04200	HEAT PIPES FOR NON-	WETTING FLUIDS=

'WITH ' NOT INDEXED

05400 T PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS= HEA
05700 T PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS= HEA

G.3 AUTHOR INDEX

HEAT PIPE RELATED PATENTS

04000	ANAND D K
01200	BACKSTROM S M
00700	BAILEY E G
04200	BIENERT W B
04500	BIENERT W B
00200	BISSELL R E
02800	BOHDANSKY J
03200	BOHDANSKY J
03600	BOHDANSKY J ET AL
05500	BROADWELL J E
04600	BROMBERG R ET AL
03200	BUSSE C A
02800	BUSSE C A
05000	BYRD A W
05600	BYRD A W
06100	BYRD A W
03500	CLINE R E
05800	EASTMAN G Y
01800	EKELUND A E
04100	FIEBELMANN P
03700	FIEBELMANN P
00500	FIENE M E
01100	GAUGLER R S
00800	GAUGLER R S
00900	GAUGLER R S
00100	GAY F W
02800	GROVER G M
03200	GROVER G M
02500	GROVER G M
02900	GROVER G M ET AL
03900	HALL W B ET AL
05500	HAMMITT A G
02600	HEEREN H
01400	HOLM S
00400	HULSE G E
05100	KEISER J T
05400	LEVEDAHL W J
04800	LEVEDAHL W J
04700	LEVEDAHL W J
05700	LEVEDAHL W J
04500	LEVEDAHL W J
04400	LEVEDAHL W J
02200	LONG E L
01700	MASLIN A J ET AL
02700	MCCORMICK H L
03000	MCDOUGAL J A
03400	MILTON R M
05300	MILTON R M
03300	NARBUT P
01600	NARBUT P
01500	NARBUT P
01300	NAREUTOVSKIH P
04300	RASPET D
02300	RODGERS J S

00300	SCHLUMBOHM P
03100	SCHRAITH E F ET AL
04900	SHLOSINGER A P
06000	SHLOSINGER A P
02000	SNELLING C D
01900	STEELE R C
01000	STIVIN J
04500	STREB A J
03800	SWET C J
02400	TALCOTT R C
00600	VERNET S
02100	WYATT T
05200	WYATT T

G.4 PATENT NUMBER INDEX

HEAT PIPE RELATED PATENTS

'BRIT ' NOT INDEXED
'CANA ' NOT INDEXED
'PATENT ' NOT INDEXED
'S ' NOT INDEXED
'U ' NOT INDEXED

03200	CANA PATENT 0765919=
04500	BRIT PATENT 1160568=
04800	BRIT PATENT 1182799=
00100	U.S. PATENT 1754314=
00200	U.S. PATENT 1786285=
00300	U.S. PATENT 1975868=
00400	U.S. PATENT 2010431=
00500	U.S. PATENT 2026423=
00600	U.S. PATENT 2028260=
00700	U.S. PATENT 2279548=
00800	U.S. PATENT 2350348=
00900	U.S. PATENT 2448261=
01000	U.S. PATENT 2466565=
01100	U.S. PATENT 2517654=
01200	U.S. PATENT 2581347=
01300	U.S. PATENT 2711882=
01400	U.S. PATENT 2840351=
01500	U.S. PATENT 2875263=
01600	U.S. PATENT 2924635=
01700	U.S. PATENT 2961476=
01800	U.S. PATENT 2978797=
01900	U.S. PATENT 3018087=
02000	U.S. PATENT 3112890=
02100	U.S. PATENT 3152774=
02200	U.S. PATENT 3217791=
02300	U.S. PATENT 3217799=
02400	U.S. PATENT 3227905=
02500	U.S. PATENT 3229759=
02600	U.S. PATENT 3273599=
02700	U.S. PATENT 3287906=
02800	U.S. PATENT 3302042=
02900	U.S. PATENT 3305005=
03100	U.S. PATENT 3330130=
03000	U.S. PATENT 3332476=
03300	U.S. PATENT 3371298=
03400	U.S. PATENT 3384154=
03500	U.S. PATENT 3399717=
03800	U.S. PATENT 3402761=
03600	U.S. PATENT 3402767=
03700	U.S. PATENT 3403075=
03900	U.S. PATENT 3405299=
04000	U.S. PATENT 3414050=
04100	U.S. PATENT 3414475=
04200	U.S. PATENT 3435889=
04300	U.S. PATENT 3437847=
04400	U.S. PATENT 3457436=
04600	U.S. PATENT 3465813=
04700	U.S. PATENT 3498369=
04900	U.S. PATENT 3502138=

HEAT PIPE RELATED PATENTS

05000	U.S. PATENT 3509386=
05100	U.S. PATENT 3516487=
05200	U.S. PATENT 3517730=
05300	U.S. PATENT 3523577=
05400	U.S. PATENT 3528494=
05500	U.S. PATENT 3532159=
05700	U.S. PATENT 3537514=
05600	U.S. PATENT 3537515=
06000	U.S. PATENT 3543839=
05800	U.S. PATENT 3543841=
06100	U.S. PATENT 3548930=